

OFFICE OF NAVAL INTELLIGENCE.

GENERAL INFORMATION SERIES, No. XXI.

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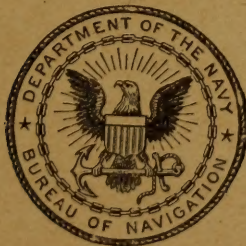
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NOTES

ON

NAVAL PROGRESS.

JULY, 1902.



OFFICE OF NAVAL INTELLIGENCE.

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INTRODUCTION.

This number of Notes on Naval Progress includes features of general naval interest which have been compiled since July 1, 1901. The principal items are as follows:

Chapter I.—Record of ships building abroad; accounts of steam trials; reconstruction of old ships; and coaling records.

Chapter II.—Tests of armor plates hardened by the Beardmore process, and the tests of capped projectiles during which a 6-inch shot pierced a 12-inch Krupp plate. Improved target practice in the British navy, and description of the Scott machine. An improved method of manufacturing gun-cotton charges. Accidental explosions on board ship and ashore.

Chapter III.—Important boiler trials of the British cruisers *Minerva* and *Hyacinth*, to which a portion of the Admiralty report is appended. Also notes on the recent trials of coaling at sea with the Temperley-Miller transporter by the British Admiralty. Full notes on recent widespread extension of liquid fuel firing for steamers.

Chapter IV.—General review of electrical progress, special notice being given to electrical steering gear.

Chapter V.—Descriptions are given of some of the principal systems of wireless telegraphy, as well as the progress made therein by foreign navies. The question of syntony is discussed.

Chapter VI.—The English maneuvers are of special interest as being the most extensive yet held, and as allowing the greatest freedom of action on the part of the commanders-in-chief. The points of interest in the French maneuvers are, first, the system denoting the fighting value of ships; second, the authority invested in the commander in chief to reassign fighting values, and restore to active service ships placed out of action, etc., in order to prevent the maneuvers from prematurely coming to an end without the desired lessons and experience being obtained; and third, the disposition of the enemy, which disposition suggests the idea that France is at war with an alliance of two powers.

Chapter VII.—The most interesting item is that of the development of the personnel of the German navy, as indicated by an examination of the budgets.

Chapter VIII.—The translation of an interesting article on battleship design by the designer of the Italian battleship *Vittorio Emanuele*.

CHARLES D. SIGSBEE,

Captain, U. S. N., Chief Intelligence Officer.

NAVY DEPARTMENT, *July 1, 1902.*

Approved.

H. C. TAYLOR,

Chief of Bureau of Navigation.

I.

NOTES ON SHIPS AND TORPEDO BOATS.

By Lieutenant-Commander J. H. GIBBONS, United States Navy,
Staff Intelligence Officer.

SECTION I.

BUILDING, ORDERED, AND PROPOSED.

CONSTRUCTION ABROAD.

The construction of ships for the fleets of the leading naval powers has gone on actively during the past year, and the new estimates show either an adherence to a well-defined program for a steady increase, or a desire to make such additions as the present financial condition of the various countries warrants. While there has been no marked change in the design of ships, the tendency has been toward greater displacement in battleships and armored cruisers, better protection, and the massing of guns of the second caliber in a central citadel instead of separating them in casemates. Italy has authorized three more ships of the *Vittorio Emanuele* type, which, with a displacement of 12,625 tons, will carry a main battery of two 12-inch guns in hooded barbettes, and twelve 8-inch guns in turrets, and have a speed of 22 knots.

France continues to lead in the number of submarine and submersible torpedo boats laid down, and experiments are going on with those already launched. England has launched five submarines recently authorized, and experiments are now going on to determine the value of the design. Austria, Italy, Russia, Sweden, and some of the South American States are experimenting with different types of submarines.

The following tables of ships laid down and ships launched contain the names of all ships concerning which definite information has been

received, but in the case of torpedo boats such information is frequently incomplete:

SHIPS LAID DOWN SINCE LAST REPORT.

AUSTRIA.

Name.	Class.	Tonnage.	Place.	Date.
"B" (Ersatz Drache) . .	Battleship, first-class	10,000	Trieste	Jan. —, 1902.

ENGLAND.

Dominion	Battleship, first-class	16,350	Barrow	May 23, 1902.
King Edward VII	do	16,350	Devonport	Mar. 8, 1902.
Devonshire	Armored cruiser	10,400	Chatham	Mar. 25, 1902.
Cadmus	Sloop	1,070	Sheerness	Mar. 11, 1902.
Clio	do	1,070	do	Do.

FRANCE.

Patrie	Battleship, first-class	14,865	La Seyne	— —, 1902.
République	do	14,865	Brest	Dec. 2, 1901.
Amiral Aube	Armored cruiser	10,000	St. Nazaire	Aug. 9, 1901.
Victor Hugo	do	12,550	Toulon	Mar. —, 1901.
Are	Torpedo-boat destroyer	1003	Chalon	— —, 1901.
Baliste	do	303	Rouen	Do.
Bélier	do	303	Nantes	Do.
Bombarde	do	1003	Havre	Do.
Catapulte	do	303	do	Do.
Dard	do	303	Rouen	Do.
Francisque	do	303	Rochefort	Do.
Mousqueton	do	303	Chalon	Do.
Pistolet	do	303	Nantes	Do.
Sabre	do	303	Rochefort	Do.
Épieu ^a	do	303	Havre	Apr. —, 1901.
Fronde ^a	do	303	do	Do.
Harpon ^a	do	303	do	Do.
Javeline ^a	do	303	St. Nazaire	Do.
Mousquet ^a	do	303	do	Do.
Sagaie ^a	do	303	Havre	Mar. —, 1901.
266 to 276	First-class torpedo boats	90	Private yards	— —, 1901.
277	First-class torpedo boat	90	Saigon	Do.
Alose	Submarine	70	Toulon	Do.
Anguille	do	70	do	Do.
Bonite	do	70	do	Do.
Castor	do	70	Rochefort	Do.
Dorade	do	70	Toulon	— —, 1901.
Esturgeon	do	70	do	Do.
Grondin	do	70	do	Do.
Loutre	do	70	Rochefort	Do.
Ludion	do	70	Cherbourg	Do.
Lynx	do	70	do	Do.
Méduse	do	70	Rochefort	Do.

^a These destroyers are not mentioned in the budget as having been laid down in 1901, but appear in the "Liste de la Flotte," January, 1902, as being under construction.

Ships Laid Down Since Last Report—Continued.

FRANCE—Continued.

Name.	Class.	Tonnage.	Place.	Date.
Naiade	Submarine	70	Cherbourg	— —, 1901.
Otarie	do	70	Rochefort	Do.
Oursin	do	70	do	Do.
Perle	do	70	Toulon	Do.
Phoque	do	70	Rochefort	Do.
Protée	do	70	Cherbourg	Do.
Souffleur	do	70	Toulon	Do.
Thon	do	70	do	Do.
Truite	do	70	do	Do.

GERMANY.

"H"	Battleship, first-class	13,000	Kiel	— —, 1901
"J"	do	13,000	Danzig	Do.
Ersatz König Wilhelm (Ex-C)	Armored cruiser	8,870	Hamburg	Do.
"J"	Protected cruiser, third-class	2,800	Kiel	Do.
G-111	Torpedo-boat destroyer		do	Do.
G-112	do		do	Do.
G-113	do		do	Do.

ITALY.

Regina Elena	Battleship, first class	12,500	Spezia	Sept. —, 1901
Vittorio Emanuele	do	12,500	Castellamare	Sept. 18, 1901

RUSSIA.

Kniaz Suvaroff	Battleship, first-class	13,600	St. Petersburg	Sept. 8, 1901
Slava	do	13,500	do	— —, 1901
Kagul	Protected cruiser, first-class	6,500	Nicolaieff	Sept. 5, 1901
Oleg	do	6,395	St. Petersburg	— —, 1901
Otchakoff	do	6,500	Sevastopol	Aug. 28, 1901
Almas	Protected cruiser, second-class	3,285	St. Petersburg	— —, 1901
Izumrud	do	3,285	Nievski	June 14, 1902
Jemtchug	do	3,285	do	Do.
Kalgoula	do	3,000	Nicolaieff	Sept. —, 1901
Kamchatka	Collier	7,200	St. Petersburg	— —, 1901

SHIPS LAUNCHED SINCE LAST REPORT.

AUSTRIA.

Name.	Class.	Tonnage.	Built at—	Laid down.	Launched.
Arpad	Battleship, first-class	8,340	Trieste		Sept. 11, 1901

Ships Launched Since Last Report—Continued.

ENGLAND.

Name.	Class.	Ton- nage.	Built at—	Laid down.	Launched.
Cornwallis	Battleship, first-class ...	14,000	Blackwall	July 13, 1899	July 17, 1901
Exmouth	do	14,000	Birkenhead	Aug. 10, 1899	Aug. 31, 1901
Prince of Wales	do	15,000	Chatham	Mar. 20, 1901	Mar. 25, 1902
Queen	do	15,000	Devonport.....	Mar. 12, 1901	Mar. 8, 1902
Bedford	Armored cruiser.....	9,800	Glasgow	Feb. 19, 1900	Aug. 31, 1901
Essex	do	9,800	Pembroke	Jan. 1, 1900	Aug. 29, 1901
King Alfred	do	14,100	Barrow	Aug. 11, 1899	Oct. 28, 1901
Lancaster	do	9,800	Newcastle	Mar. 4, 1901	Mar. 22, 1902
Leviathan	do	14,100	Glasgow	Nov. 30, 1899	July 3, 1901
Monmouth	do	9,800	do	Aug. 29, 1899	Nov. 13, 1901
Challenger	Protected cruiser, sec- ond-class.	5,880	Chatham	Dec. 1, 1900	May 27, 1902
Encounter	do	5,880	Devonport.....	Jan. 28, 1901	June 18, 1902
Merlin	Sloop	1,100	Sheerness	Feb. 11, 1901	Nov. 30, 1901
Odin	do	1,100	do	do	Do.
Moorhen	Shallow-draft gunboat ..	180	Poplar	Oct. 17, 1900	Aug. 13, 1901
Arab	Torpedo-boat destroyer.	430	Glasgow	— —, 1900	Feb. 9, 1901
Success	do	360	Sunderland	Mar. 30, 1899	Mar. 21, 1901
No. 107.....	Torpedo boat, first-class.	150	Chiswick .....	.....	July 2, 1901
No. 108.....	do	150	do	Sept. 5, 1900	Aug. 30, 1901
No. 1.....	Submarine boat	120	Barrow	— —, 1901	Oct. 2, 1901
No. 2.....	do	120	do	do	Feb. 21, 1902
No. 3.....	do	120	do	do	May 9, 1902
No. 4.....	do	120	do	do	May 23, 1902
No. 5.....	do	120	do	do	June 10, 1902

FRANCE.

Amiral Aube.....	Armored cruiser.....	10,000	St. Nazaire	Aug. 9, 1901	May 9, 1902
Condé	do	10,000	Lorient	Mar. 20, 1901	Mar. 12, 1902
Dupetit Thouars	do	9,500	Toulon	Apr. 17, 1899	July 5, 1901
Léon Gambetta.....	do	12,550	Brest	Jan. 15, 1901	Oct. 26, 1901
Rapière	Torpedo-boat destroyer.	303	Rochefort	Jan. 2, 1901	July 16, 1901
Flamberge	do	303	do	do	Oct. 28, 1901
Bourrasque.....	Seagoing torpedo boat..	150	Havre	June 28, 1900	Aug. 31, 1901
Rafale	do	150	do	July 15, 1900	Nov. 27, 1901
143.....	Torpedo boat, second- class.	52	Toulon	Jan. 2, 1901	— —, 1902
223.....	Torpedo boat, first-class.	84	Cherbourg.....	Sept. 3, 1900	Mar. 11, 1902
224.....	do	87	do	Apr. 28, 1897	— —, 1901
225.....	do	86	Toulon	— —, 1896	Mar. 20, 1902
226.....	do	87	do .....	.....	— —, 1901
253.....	do	90	Havre	Jan. —, 1900	Aug. 16, 1901
254.....	do	90	do	Mar. —, 1900	Sept. 27, 1901
255.....	do	91	do	Aug. —, 1900	Oct. 31, 1901
256.....	do	91	do	Nov. —, 1900	Nov. 29, 1901
257.....	do	91	do	Dec. —, 1900	Feb. 11, 1902
258.....	do	91	Bordeaux	Nov. 15, 1900	— —, 1901
259.....	do	91	do	do	Oct. 3, 1901
260.....	do	91	do	do	Oct. 31, 1901
264.....	do	91	do .....	.....	Dec. 12, 1901
265.....	do	90	do .....	.....	Feb. 22, 1902

a Omitted from last report.

Ships Launched Since Last Report—Continued.

FRANCE—Continued

Name.	Class.	Ton- nage.	Built at—	Laid down.	Launched.
Espadon	Submarine	106	Cherbourg .....	.....	Aug. 31, 1901
Gnome	do	185	Rochefort .....	.....	— —, 1901
Korrigan	do	185	do	Apr. 23, 1900	Jan. 25, 1902
Silure	do	106	Cherbourg .....	.....	Oct. 29, 1901
Triton	do	106	do	Aug. 28, 1900	July 13, 1901

GERMANY.

Mecklenburg (Ex-F).	Battleship, first-class ...	11,800	Stettin	May 15, 1900	Nov. 9, 1901
Schwaben (Ex-G).	do	11,800	Wilhelmshaven ..	Oct. 18, 1900	Aug. 19, 1901
Prince Frederick Karl.	Armored cruiser	8,868	Hamburg	— —, 1901	June 21, 1902
Frauenlob (Ex-G).	Protected cruiser, third-class.	2,700	Bremen	— —, 1901	Mar. 22, 1902
Arcona (Ex-H).	do	2,700	do	do	Apr. 22, 1902
S-105	Torpedo-boat destroyer.	420	Elbing	Dec. 4, 1900	Aug. 7, 1901
S-106	do	320	do	do	Sept. 7, 1901
S-107	do	420	do	Jan. —, 1901	Oct. 17, 1901
G-108	do	320	Kiel	Dec. —, 1900	Sept. 7, 1901
G-109	do	320	do	do	Do.
G-110	do	320	do	do	Apr. 2, 1902
G-111	do	320	do	— —, 1901	June 19, 1902

HOLLAND.

Rindjani	Torpedo boat, first-class.	115	Poplar		July 2, 1901
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ITALY.

Benedetto Brin....	Battleship, first-class ...	13,500	Castellamare	Feb. —, 1899	Nov. 7, 1901
Francesco Ferruccio.	Armored cruiser	7,400	Venice .....	.....	Apr. 23, 1902
Turbine	Torpedo-boat destroyer.	330	Naples .....	.....	Nov. 21, 1901

JAPAN.

Akatsuki	Torpedo-boat destroyer.	360	Poplar .....	.....	Nov. 13, 1901
Asashio	do	360	Chiswick .....	.....	Jan. 10, 1902
Kasumi	do	360	Poplar .....	.....	Jan. 23, 1902
Shirakumo	do	360	Chiswick	Feb. 28, 1901	Oct. 1, 1901

PORTUGAL.

Tejo	Gunboat	530	Lisbon		Oct. 28, 1901
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Ships Launched Since Last Report.

RUSSIA.

Name.	Class.	Tonnage.	Built at—	Laid down.	Launched.
Borodino	Battleship, first-class ...	13,600	St. Petersburg ...	May 25, 1900	Sept. 8, 1901
Imperator Alex- ander III.	do	13,600	do	do	Aug. 2, 1901
Orel	do	13,600	do	June 11, 1900	June —, 1902
Okean	Training transport	12,000	Kiel	June 1, 1901	Feb. 8, 1902
Baklan	Torpedo-boat destroyer.	240	St. Petersburg		Aug. 12, 1901
Kefal	do	312	Toulon	Mar. —, 1899	Nov. 28, 1901
Losos	do	312	do	July —, 1899	Mar. 12, 1902
Akula	Torpedo boat	150	St. Petersburg		Aug. 24, 1901
Buichok	do	150	do		Do.
Makrel	do	150	do		Oct. 12, 1901
Nalim	do	150	do		Do.

SWEDEN.

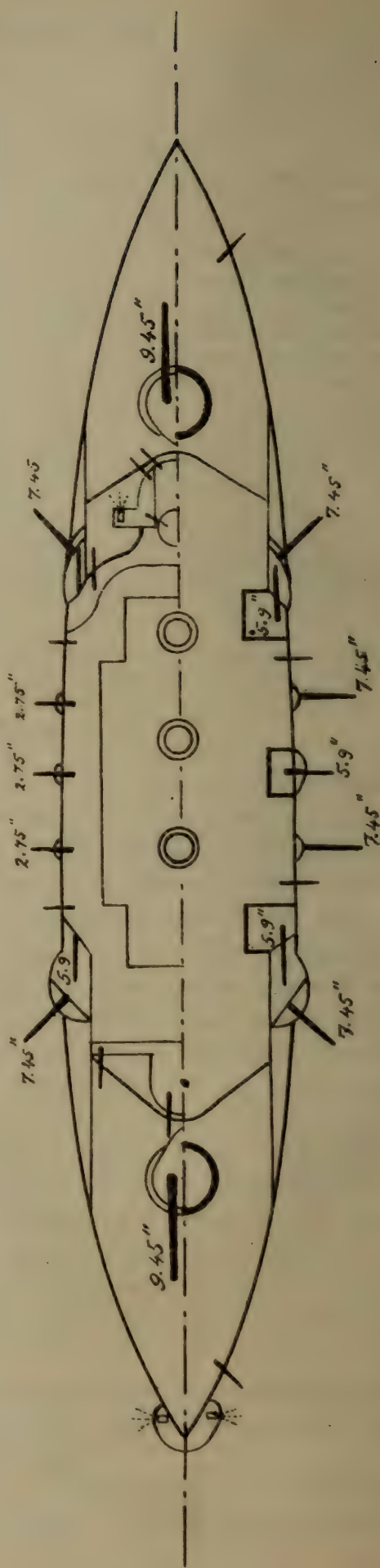
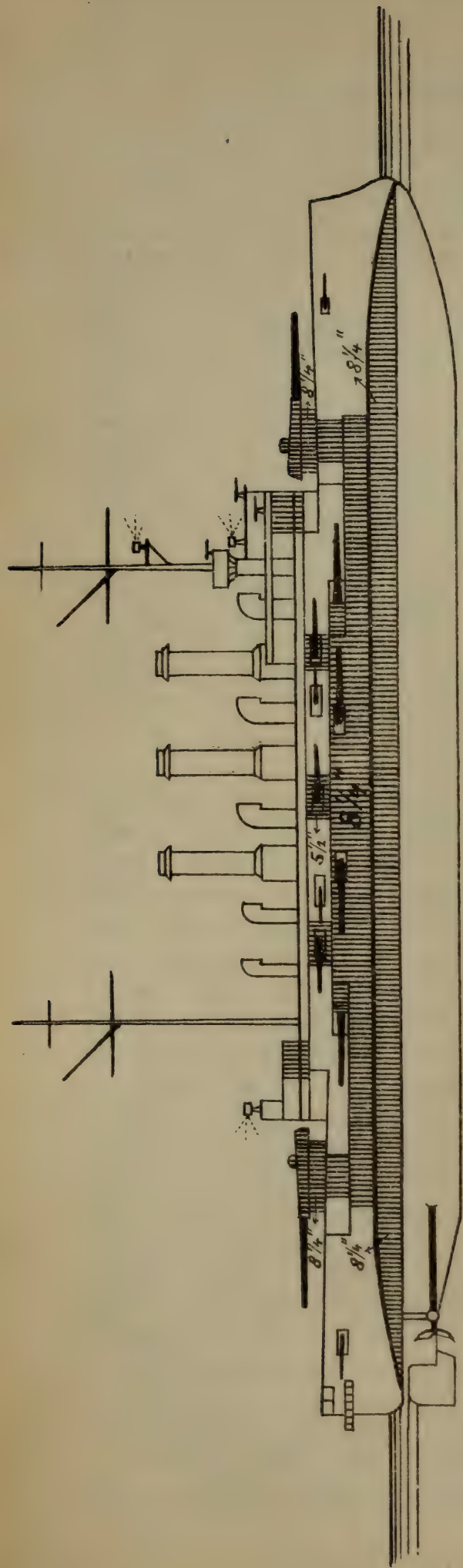
Aeren (Ex-C)	Battleship, third-class..	3,650	Gotaborg	Apr. —, 1900	Aug. —, 1901
Tapperheten (Ex- A).	do	3,650	Malmo	do	Oct. —, 1901
Wasa (Ex-B)	do	3,650	Stockholm	do	Sept. 25, 1901

ARGENTINA.

Two armored cruisers, to be known as the *General Mitra* and the *General Roca*, have been ordered in Italy by the Argentine Government. They are to be built at the Ansaldo Works, at Genoa, and a large premium has been promised for their delivery within contract time. These ships are to be of the *Garibaldi* type, 8,500 tons displacement, 17,000 I. H. P., and 21 knots speed. The estimated cost of each ship is \$3,400,000. The first of these ships was laid down March 14, 1902, and the second March 29, 1902. Their armament will be the same as that of the Italian armored cruiser *Francesco Ferruccio*, the guns that were made for the latter ship having been sold to Ansaldo. A duplicate battery is now being made at Pozzuoli for the *General Roca*, and another duplicate to replace those originally for the *Francesco Ferruccio*. One novel feature is that these ships are to have the old cylindrical boilers. The firm of Ansaldo & Co. wanted to have the Niclausse boilers, which have proven so successful in the Italian cruiser *Garibaldi*, but the Argentine Government insisted upon having the cylindrical boilers, which they state are known to be good.

Two dispatch boats have been laid down at the Government yard in Buenos Ayres. They are to be of 700 tons displacement and 14 knots speed, and are to be used as practice ships.

A submarine boat, the *Ricaldoni*, is reported to have made trial trips at Buenos Ayres with good results. It is intended to build a



*Ersatz "Laudon", —
Austrian Battleship, 10,600 Tons.*

larger boat of the following dimensions: Length 131 feet; beam, 16.4 feet. The speed is to be 11 knots, and the steaming radius 435 miles.

AUSTRIA.

Battleships "A" (*Ersatz Laudon*) and "B" (*Ersatz Drache*), each of 10,600 tons displacement, will be built by the Stabilimento Tecnico, at Trieste, to which firm the contract was given last year. The first of these has been laid down, but the second will not be laid down probably until the fall of 1902. A third battleship, "C," of the same class, is proposed. These ships will be of the following dimensions: Length, 390.4 feet; beam, 72.18 feet; draft, 24.6 feet; displacement, 10,600 tons; I. H. P., 14,000; speed, 19 knots.

The armament, built on the Skoda system, will consist of four 9.45-inch R. F. guns mounted in turrets, with 8.27 inches of armor; eight 7.5-inch R. F. guns in citadel; six 5.9-inch R. F. guns in single casemates with 5.5 inches of armor; fourteen 2.75-inch R. F. guns; twelve 37-millimeter R. F. guns; and four automatic rifles.

The water-line and citadel armor is 8.27 inches thick. There is an armor deck 1.97 inches thick within the citadel, and 2.75 inches thick outside of the citadel. The armor belt, which is of nickel-steel, extends from the forward turret to the after turret. A number of torpedo tubes are to be carried. The boilers are to be of the Yarrow type.

BRAZIL.

The Brazilian congress has passed an act authorizing the construction of a submarine torpedo boat which must be of national invention and design. Another act authorizes the construction of two monitors out of any unexpended funds appropriated for the navy. No other additions to the navy are contemplated.

CHILE.

It is reported that the Chilean Government has ordered two battleships of 12,000 tons each, to be built in England. These vessels are to cost about \$4,800,000, and are to be delivered within eighteen months. The following are the dimensions: Length, 435 feet; beam, 70 feet; I. H. P., 25,000; speed, 21 knots. Each ship will carry four 10-inch guns, fourteen 7.5-inch guns, and many smaller rapid-fire guns.

The *Fourth of July*, a sister ship of the Japanese protected cruiser *Takasago*, built at Elswick, England, as a speculation, has been purchased by Chile and named *Chacabuco*.

Three destroyers have been purchased in England by Chile, viz, *Capitan Thomson*, *Capitan Merino Tarpa*, and *Capitan O'Brien*. These are said to be Yarrow boats of 130 tons displacement.

ENGLAND.

The new vessels authorized by the budget of 1902-3 are 2 battle-ships, 2 armored cruisers, 2 third-class cruisers, 4 scouts, 9 torpedo-boat destroyers, 4 torpedo boats, and 4 submarines.

The following is a list of the new vessels authorized to be laid down in 1901-2, which have been ordered:

Name.	Class.	Tons.	To be built at—
King Edward VII	Battleship	16,350	Devonport.
Dominion	do	16,350	Barrow.
Commonwealth	do	16,350	Glasgow.
Devonshire	Armored cruiser	10,200	Chatham.
Argyll	do	10,200	Greenock.
Antrim	do	10,200	Glasgow.
Carnarvon	do	10,200	Do.
Hampshire	do	10,200	Newcastle-on-Tyne.
Roxburgh	do	10,200	Glasgow.
Amethyst	Protected cruiser	3,000	Do.
Topaz	do	3,000	Do.
Cadmus	Sloop	1,070	Sheerness.
Clio	do	1,070	Do.
10 vessels	Torpedo-boat destroyers		Various.
5 vessels	Torpedo boats		Chiswick.
Aquarius	Distilling ship		Sunderland.

The main features of the *King Edward VII* class of battleships are as follows:

Length, 425 feet; beam, 78 feet; mean draft, 26 feet 9 inches; displacement, 16,350 tons; I. H. P., 18,000; expected speed, 18½ knots; coal carried at designed L. W. L., 950 tons; bunker capacity 2,000 tons.

Armament—Four 12-inch guns, four 9.2-inch guns, ten 6-inch guns, fourteen 12-pounders, eight machine guns, four submerged torpedo tubes and one stern tube.

Armor—Water-line belt, 9 inches to 4 inches in thickness. Between middle and main decks 8 inches in thickness. Between main and upper decks, for length of 6-inch battery, 7 inches in thickness. Barbettes, 12 inches. Conning tower, 12 inches.

The armored cruisers of the *Devonshire* class are to be about 400 tons larger than those of the *Monmouth* class. Their principal armament will consist of two 7.5-inch R. F. guns in two shallow barbettes, instead of four 6-inch R. F. guns; the ten 6-inch R. F. guns in casemates will be repeated. The vessels will be 10 feet longer and 1 foot wider than the *Monmouth* class. The mean load draft is to be 24 feet 6 inches, and the estimated speed 23 knots, with 22,000 I. H. P.

Four-fifths of the boilers in each ship are to be water-tubular and

one-fifth cylindrical, the former including the Babcock and Wilcox, Nielausse, Yarrow, and Dürr types.

The two third-class protected cruisers are an improvement on the *Pelorus* class, being larger, faster, and more powerfully armed. Their length is 360 feet; beam, 40 feet; molded depth, 21 feet 9 inches; draft, 14 feet 6 inches; speed, $21\frac{3}{4}$ knots, with 9,800 I. H. P. The armament will consist of twelve 4-inch R. F. guns, and eight 3-pounder R. F. guns.

The two sloops are similar in dimensions, armament, etc., to the *Espiegle*, recently completed at Sheerness.

The ten new torpedo-boat destroyers will be of a modified type, of larger displacement, stronger construction, and with improved accommodations for officers and crew as compared with existing vessels of this class. These modifications will tend to improve the seagoing qualities of the vessels. The official trials will be made, however, at deep-load draft, a speed of $25\frac{1}{2}$ knots under these conditions being specified.

FRANCE.

The French budget of 1902 provides for the laying down of 1 battleship, 2 armored cruisers of the *Leon Gambetta* type, 2 destroyers, and 16 torpedo boats. In addition, material is to be ordered for 3 battleships to be laid down in 1903; and orders are to be placed for 13 submarines, with the understanding that they shall not be begun until 1903. After the laying down of these vessels, the status of the naval programme for the increase of the French fleet will be as follows: 6 battleships and 5 armored cruisers, the total number contemplated, will have been commenced; of the 28 destroyers, 22 will have been commenced; of the 112 torpedo boats, 41 will have been commenced, and, although the programme only stipulated for the building of 26 submarines, 44 will have been built or be in course of construction, and it is proposed to go on adding to their number.

The four new battleships are to be named *Democratie*, *Liberté*, *Justice*, and *Verité*. One of these is to be built at Brest, and three in private yards. One armored cruiser, to be named *Jules Michelet*, is to be begun at Lorient, and the other, to be known as the *Ernest Renan*, is to be built at a private yard. The 2 destroyers are to be built at Rochefort, the 13 submarines at Cherbourg and Toulon, 1 torpedo boat at the Government arsenal in Saigon, and 12 torpedo boats at private yards. The new submarines are to be of the improved *Sirène* type. The two destroyers have been named *Stylet* and *Tromblon*, and will be of the *Carabine* type.

The armored cruiser *Jules Michelet*, according to the latest reports, is to be 480 feet long and of 12,550 tons displacement, with a speed of 22 knots. Her armament will consist of four 7.6-inch R. F. guns in

two turrets; twelve 6.5 R. F. guns, mounted in pairs in turrets, and four in armored casemates, and twenty-two 1.85-inch R. F. guns. The estimated cost of this ship is \$5,991,860.

GERMANY.

The rapid progress made in carrying out the German building program strengthens the impression that the battle fleet will be completed in 1908, when it will consist of 38 battleships. Although some of these will have passed, by that time, the age limit of twenty-five years, the *Sachsen* and *Siegfried* classes will have been entirely rebuilt.

In 1902 there are to be laid down 2 battleships, K and L; 1 armored cruiser, *Ersatz Kaiser*; 3 small cruisers, K, L, and *Ersatz Zieten*; 1 gunboat, B (extra to program); one division (6) of torpedo-boat destroyers, and 1 gunboat for service in Chinese rivers. The budget also includes the first installment of an appropriation for rebuilding the *Brandenburg* class of battleships.

The new battleships are to be of 13,000 tons displacement, of the same type as H and J laid down in 1901. The armament will consist of 11-inch and 7-inch guns.

It is stated that the *Ersatz Kaiser* is to represent a new type of armored cruiser, her displacement being 500 tons more than that of the last built ship of this class. The principal dimensions are to be: Length between perpendiculars, 403.5 feet; length over all, 419 feet; beam 66.3 feet. The horse-power, which in the case of the *Prinz Heinrich* is 15,000, *Prinz Adalbert* 16,500, and *Ersatz König Wilhelm* 17,000, is to be further increased in the case of the *Ersatz Kaiser*. She will carry a crew of 550 officers and men.

The small cruisers are to have the following dimensions: Length, 361 feet; beam, 40.3 feet; displacement, 2,715 tons. Their coal capacity is to be 700 tons, and they will have a maximum speed of 24 knots, an increase of 2 knots over that of the *Frauenlob* and *Arcona*.

The gunboat for service in China is the first one of that class to be built in Germany; the other two, the *Vorwärts* and *Schamien*, having been purchased and refitted at Shanghai and Hongkong, respectively. The new gunboat B is not to be built after the plans of the *Panther*, but is to have somewhat larger dimensions.

ITALY.

The Italian budget for 1902 provides for the laying down during the year of 3 battleships of the *Vittorio Emanuele* type, 2 colliers, 2 torpedo-boat destroyers, 1 submarine, 4 seagoing torpedo boats, and 1 repair ship.

Of the three new battleships to be laid down, the first, A, will take the place of the *Benedetto Brin* on the stocks at Castellamare; the second, B, that of the *Regina Margherita* at Spezia; and the third, C,

which is to be called the *Roma*, that of the *Francesco Ferruccio* at Venice. The first installment of the appropriation for these ships is only \$330,480.

JAPAN.

The program for new construction in Japan is at present confined to cruisers and torpedo boats to be built at home yards. Although the conditions at the Government steel works at Wakamatsu have not as yet been satisfactory, better results are expected, and some of the latest contracts for torpedo boats stipulate that they shall be built entirely of domestic material.

Five new torpedo boats of 150 tons each are to be built, their names and places of construction being as follows: *Sagi*, *Uzura*, and *Kamone* to be built at Kure; *Hashitaka* and *Otori* at Kawasaki Shipbuilding Yard.

There have also been ordered 2 first-class torpedo boats of 120 tons displacement and 28 knots, of the Kawasaki Works at Kobe, to be delivered within two years. Exclusive of the armament, which is to be furnished by the arsenal at Kure, each of the boats is to cost \$144,942.

MEXICO.

An order for two gunboats for the Mexican navy has been given to the Crescent Shipbuilding Company, Elizabethport, N. J. These vessels are to be 200 feet long, 33 feet beam, and to have a draft of 10 feet; displacement, 1,000 tons. They will also be used as transports, accommodations being provided for 200 soldiers.

NICARAGUA.

It is reported that the Government of Nicaragua has purchased in Germany the armored gunboat *Skorpion*, of 1,109 tons, which was built at Bremen in 1877.

NORWAY.

The budget for 1902 provides for a dispatch vessel of 850 tons and two second-class torpedo boats. The Norwegian Government is contemplating the construction of a submarine boat, and a naval officer has been visiting several countries in order to study the different types. The boat will probably be built at Horten.

RUSSIA.

No plan has been formed for the building of new ships beyond the carrying out of the program of 1899. There have been laid down under this program 7 battleships, of which 4 have been launched.

There are now building in Russian shipyards 5 protected cruisers of about 6,500 tons, of which 3 have been launched. The Russian Government has not yet decided whether the cruiser *Vityas*, which was burned while building at Galernii Island, St. Petersburg, will be recommenced. It is reported that no new program will be adopted before 1905.

A new cruiser of the *Novik* type has been ordered of Schichau, at Elbing. She is intended to be a destroyer of torpedo-boat destroyers and will have a speed of 25 knots. Her length will be 357.5 feet; displacement, 3,000 tons, and her engines 17,000 I. H. P. She will have a turret forward protected by 2-inch Krupp plates, in which will be placed 6 guns of large caliber, about 45-pounders. She will also carry 8 smaller guns, 2 Maxims, and 6 torpedo tubes.

Four torpedo-boat destroyers, the *Givoi*, *Givuca*, *Gintky*, and *Giarky*, are to be constructed at the Nicolaieff Arsenal, and two, the *Zavidui* and *Zavetni*, at the Nicolaieff Steel Works.

The Newski engineering works at St. Petersburg have received a contract to build 5 torpedo boats of the *Cyclone* type. The first two are to be completed in May, 1902, and will cost about \$150,000. Their dimensions are: Displacement, 150 tons; length, 147.6 feet; beam, 10.5 feet; draft, 4.6 feet; and I. H. P., 4,200. They will have two Normand boilers, each with 2,476 square feet of heating surface and 48.4 square feet of grate surface. They will use coal as fuel, and are expected to attain a speed of 25 knots. Each will have one torpedo tube above deck and two 47 millimeter guns.

Five torpedo boats of 230 tons displacement, 4,500 I. H. P., and 30 knots speed, are to be built at Ijora.

The various portions of the submarine boat *Peter Kochka*, invented by Lieutenant Kolbaseff, of the Russian navy, have been shipped to the Black Sea, where they will be assembled, and a series of experiments conducted with the boat at Sevastopol.

It is said that another submarine of an entirely different type is now building.

It is reported that Russia has offered to buy the vessels composing the Peyang squadron of the Chinese navy, viz, 4 small protected cruisers, 2 torpedo-boat destroyers, 2 training ships, and 1 special service vessel. The price set was \$2,575,000, to be deducted from the war indemnity due Russia. Since the promulgation of the Anglo-Japanese treaty, rumors have been current that Russia intends to build 4 new battleships of about 16,000 tons displacement and 2 cruisers, and that these will be ordered abroad if vacant slips can not be found at home.

The construction of a third mine transport of the same type as the *Bug* and *Dunai* of the Black Sea fleet is about to be commenced at the works of the New Admiralty. The vessel is to have a displacement

of 1,360 tons and a speed of 16 knots. Her length is to be 204 feet, beam 34 feet, and draft 15 feet. She is intended for the transportation of 425 mines, and will have an armament of four 47 millimeter guns on the upper deck.

SWEDEN.

In the naval estimates for 1902, first credits are voted for the construction of a new armored coast-defense vessel, 3 first-class and 2 second-class torpedo boats, and 1 torpedo-boat destroyer. The Admiralty has also contracted with Yarrow & Co., of Poplar, for a 31-knot destroyer, which is to be of the most modern type and fitted to burn liquid fuel.

The plans for the new coast-defense vessel are somewhat different from those of the ships of that class now building, the changes being confined to a slight reenforcement of the protective deck above the boilers and of the foundations for the 6-inch turrets and ammunition hoists, while the armor of the barbette of the 8.3-inch R. F. guns is to be slightly thinner.

As there has heretofore been considerable delay in furnishing the armor, it was decided to give the order for the whole armor, with the exception of that for the protective deck and ammunition hoists, to the firm of Krupp without calling for competitive bids.

TURKEY.

By imperial decree, the protected cruisers that Turkey is to have built by Armstrong in England and Cramp in the United States are to be named the *Abdul Hamid* and the *Abdul Medjid*.

These cruisers are to be of the following dimensions: Length, 328 feet; beam, 42.6 feet; draft, 16 feet; displacement, 3,250 tons; speed, 24 knots. The engines are to be triple expansion, designed to develop 12,000 I. H. P. The armament will consist of the following R. F. guns: Two 6-inch, seven 4.7-inch, six 1.85-inch, and six 1.4-inch. There will be two torpedo tubes.

SECTION II.

NEW SHIPS AND TORPEDO BOATS.

AUSTRIA.

ARPAD.

The new second-class battleship *Arpad* was launched on September 11, 1901, from the San Marco yard of the Stabilimento Tecnico Triestino, at Trieste. She is the second of the new division of battleships, of which the *Habsburg* is the type. They form an addition to the effective strength of the fleet, in contradistinction to the other vessels now under construction, such as the cruiser *E*, which are being built to replace ships still on the list. These ships have a displacement of 8,340 tons, or nearly 1,500 tons more than the *Kronprinz Rudolf*, which was previously the largest vessel of the fleet. They exceed the *Monarch* class, intended for coast defense, by 2,740 tons. Her dimensions are as follows:

Length, 354 feet; beam, 65 feet 9 inches; displacement, 8,340 tons, with an extreme draft of 23 feet. Protection is afforded by an armor belt of chrome-nickel steel 8.8 inches thick, reaching from 4 feet 4 inches below to 3 feet 6 inches above the water line, and extending 63 per cent of her length. Above the belt, and reaching to the main or battery deck, is a citadel protected by 4-inch armor, shut in by 8-inch athwartship bulkheads, rising from the lower armor deck, which is 2.3 inches thick forward of the casemates and 2.6 inches abaft. From the forward end of the armor belt to the ram the side is protected by 2-inch plating. A second armor deck, 1.8 inches thick, extends from the top of the belt, while the main deck, between the forward and after bulkheads, is similarly protected, the combing of all the hatches being also armored. There are two barbettes for the heavy guns, one forward and one aft, protected by 8.4-inch armor, with ammunition tubes 7.2 inches thick. The secondary battery of 6-inch R. F. guns will be mounted in double casemates, protected by 5.4-inch armor on the outer side and 3.3-inch on the inner side. The forward conning tower will be protected by 8-inch armor, decreasing to 6 inches on the communication tube. The after tower will have 4-inch armor, decreasing to 2-inch on the communication tube. All



DUNCAN. ENGLISH BATTLESHIP, 14,000 TONS.

the armor will be of chrome-nickel steel, hardened by a special process, and is to be furnished by the firm of Witkowitzk & Co.

The armament will consist of three 9.4-inch 40-caliber guns, two being carried in the forward barbette and one in the after; twelve 5.9-inch 40-caliber R. F. guns, six each side mounted in double casemates, one over the other; ten 6-pounder and twelve 1-pounder R. F. guns, with eight machine guns. The guns and ammunition hoists will be worked by either electricity or hand, while the ammunition tubes lead direct from the guns to the magazines, and it is calculated that by means of the electric hoists eight rounds a minute can be supplied. The axial height of the guns in the lower battery is 14 feet 8 inches above the water, in the upper battery 21 feet 4 inches, and that of the barbette guns 25 feet and 24 feet 4 inches forward and aft, respectively. There will be two submerged torpedo tubes for 18-inch Whitehead torpedoes. The heavy 9.4-inch guns are supplied by Krupp, but all the others are manufactured by the Skoda firm at Pilsen.

The ship will have twin screws, and the engines are to develop 11,900 I. H. P., which, with 136 revolutions, is to give a speed of 18.5 knots, steam being supplied by 16 water-tube boilers on the Belleville system. The coal stowage will be for 840 tons. Electricity will be used for lighting the ship, working the guns, barbettes, ammunition hoists, ventilators, etc., the current being supplied by six dynamos, producing three-phase currents and under armor protection.

ENGLAND.

DUNCAN CLASS.

The *Cornwallis*, launched July 17, 1901, and the *Exmouth*, launched August 31, 1901, complete the six vessels of this class, a full description of which is given on page 34, General Information Series No. XX.

PRINCE OF WALES—QUEEN.

These new battleships have been launched, the former at Chatham, March 25, 1902, and the latter at Devonport, March 8, 1902. They are practically of the *London* class, but embody certain improvements, such as the limitation of ventilating cowls, and the substitution of an open for a closed 12-pounder battery amidships. Particulars of these vessels are as follows:

Displacement, 15,000 tons; length, between perpendiculars, 400 feet; beam, 75 feet; draft (extreme), 29 feet.

Armament: Four 12-inch, wire-wound, 50-ton guns, twelve 6-inch 45-caliber Vickers, sixteen 12-pounder 12 cwt., two 12-pounder 8 cwt. (boat guns), six 3-pounders, and eight Maxims. Four 18-inch submerged torpedo tubes.

The armor consists of a Krupp cemented belt 15 feet wide, extending from the after bulkhead to the bow. It is 9 inches thick amidships,

decreasing to 6 inches just by the forward barbette, and thence reduces to 2 inches at the extreme bow. It is 4 inches thick at 30 feet from the stem, and here the belt proper ends. The continuation is 2-inch nickel steel, and it is carried down over the ram. Aft the after bulkhead, up to the level of the lower deck, there is 1 inch nickel laid on the one-half inch skin plating, constituting a complete belt against small projectiles.

There are two armor decks. The upper one is flat—1 inch thick of steel where the side armor is thickest and 2 inches elsewhere. This armor deck runs along level with the top of the belt and forms the main deck of the ship.

The second deck is the ordinary inclined deck reinforcing the belt. It rises from the lower edge of the belt amidships, and, going up at a sharp angle, has a flat top about the lower deck level in the middle of the ship. Forward and aft it sinks more and has less curve.

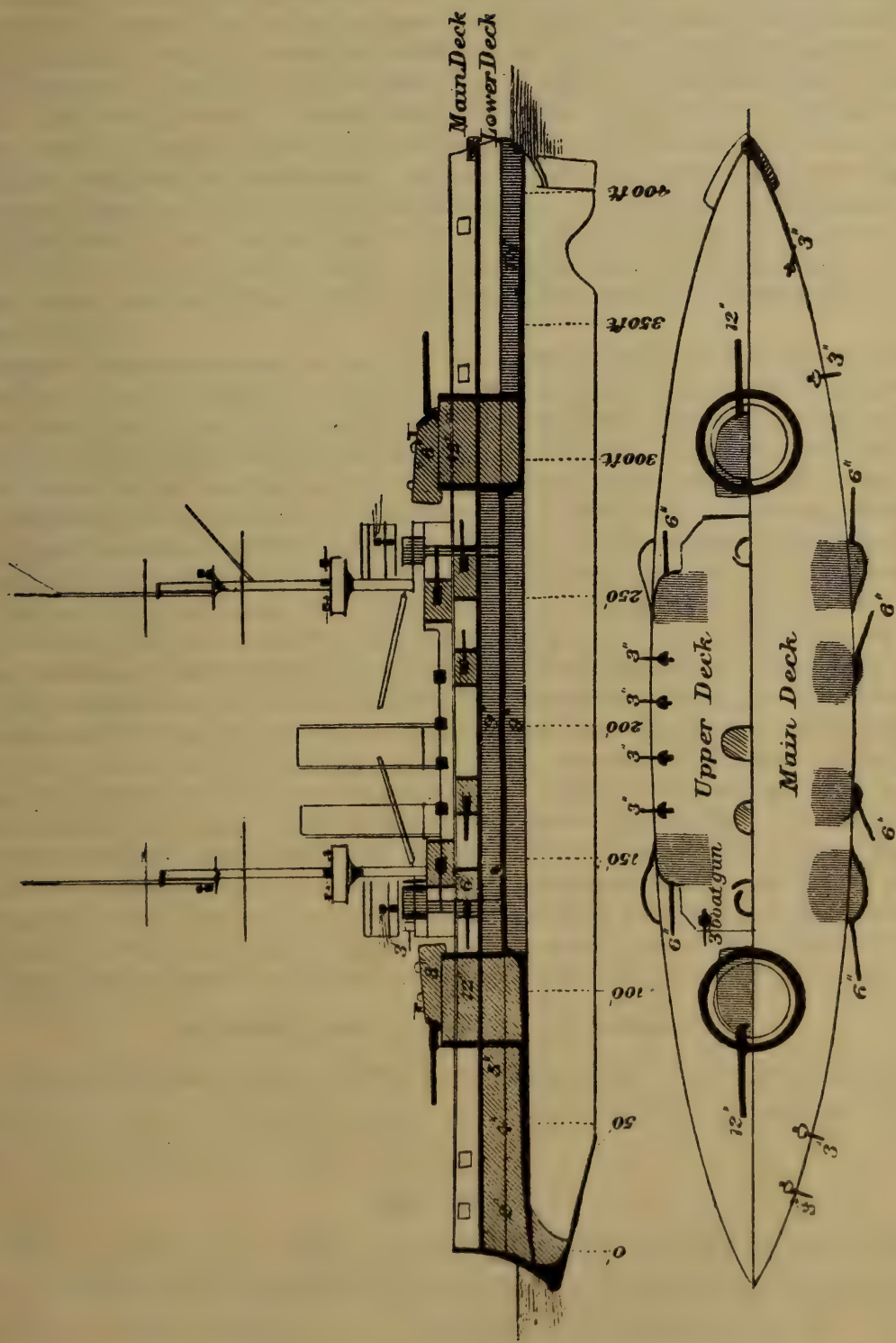
There will be two sets of vertical triple-expansion engines, actuating twin screws turning inward. They are designed for 15,000 I. H. P., which is to give 18 knots and 110 revolutions. The boilers will be twenty in number, of the Babcock & Wilcox type in the *Queen* and the Belleville in the *Prince of Wales*.

Speaking of the armament of these vessels, the London *Engineer* says:

A proposal is afoot to replace some or all of the *Queen's* 6-inch guns by 7.5 pieces, and, in view of the present trend toward arming our ships as well as any possible enemy's, this may very probably be attempted.

A 7.5-inch gun with mountings weighs approximately 27 tons, and its charge and projectile 256 pounds. With the new propellant some weight will be saved, and approximately 10 rounds go to the ton, and about 20 tons of ammunition are carried per gun at 200 rounds the gun. That is 240 tons for 12 guns, which, plus the weight of 12 guns and mounting—324 tons—comes to about 564 tons for an entire armament of 7.5-inch guns. To this we may add 75 tons for increased size of casemates, giving a grand total of 639 tons, which we may call 650 in round numbers. The 6-inch 45-caliber Vickers, with its mounting, etc., weighs 9½ tons. Weight for 12 guns is therefore 111 tons, against 324 tons. Ammunition runs at about 18 rounds to the ton. The total for all the secondary guns at 200 rounds we can put at 132 tons, giving a grand total of 143 tons for the present 6-inch armament, against 564 tons as an outside weight for one of 7.5-inch guns. The extra weight would then be about 421 tons.

Now, 50 tons, more or less, is a negligible weight in any of Sir William White's battleships—the margin in them being about 800 to 1,000 tons in 15,000. By this we mean that all of them carry maximum coal without their speed being affected. To reduce the coal would not be politic, perhaps, but the extra 420 tons odd would not very appreciably affect the speed of the *Queen*, while in any case she would consume coal enough to soon cover the difference. But the weight can be saved far more cheaply. The exact weight of "stores" carried is hard to get at, but since in dealing with a 15,000-ton total small fractions do not matter, we can arrive at an approximation sufficiently near. Something over 2 tons a day in the way of food, etc., are daily consumed by a battleship's crew. Much of it is in the way of food that is replenished weekly, but stores for six months are carried. If we assume



"QUEEN," ENGLISH BATTLESHIP, 15,000 TONS.

these at a ton a day, we shall not probably be much more than a hundredweight or so out, and the total can not be less than 200 tons. Probably, seeing that it includes many things besides food, 300 tons or more would be nearer the mark. Since a ship must coal at least once a month, a good three-quarters of these stores are dead weight of no value, and here alone nearly 200 tons could be saved.

Then, again, the 7.5-inch could do with less than 200 rounds. Fifty tons could be saved here. About 50 to 100 tons of spare gear is quite unnecessary, and thus, without touching the coal, the extra 420 to 450 tons of 7.5-inch armament is sufficiently nearly covered to insure no appreciable loss of speed. In addition, the 12-inch guns—each round for which weighs nearly half a ton—carry far more rounds than they could conceivably require. The *Queen* could not well mount more 6-inch guns than she does, save by substituting a battery a la *Mikasa* for the main deck casemates, and that means a heavy increase in weight. Four 7.5-inch could replace four 6-inch at a cost of 160 tons, on which 10 tons of ammunition at least could be saved, and that extra 150 tons, which might conceivably be considerably less, for we have taken outside weights for the extra size of casemates, could be carried without the ship feeling it.

Our own impression is that, even did it necessitate reducing the coal supply by 400 tons, the change in armament would be a gain, for the burst of these 200-pound shells from the 7.5-inch gun is prodigious, while probable enemies all carry armor that the 7.5-inch could tackle where the 6-inch could not. There is a great deal of 5-inch armor on foreign ships, and the 7.5-inch in battle conditions should be superior to that armor, and go through it whenever it hit it seven times out of ten, while a 200-pound projectile at 2,500 foot-seconds initial velocity is going to hit hard enough to make itself extremely unpleasant, even where it does not get through. Reflecting on this and kindred things, we strongly advise the Admiralty to take the bull by the horns and give the *Queen* the projected 7.5-inch guns. It is a thing that can be done, and since it can be done it should be done, for it is worth it. The 6-inch gun is either too small or too large for modern requirements, and only the fact that it is the smallest gun that can be trusted to fire lyddite that will detonate with certainty justifies its use at all. Two 4.7-inch would weigh no more and do equal execution, save with lyddite, and shoot more truly at sea. They also threaten to land us in the *reductio ad absurdum*, for the 4-inch may be better still, and so on, till we get to the 3-pounder, the most deadly gun of any, if only its range were longer. Going upward from the 6-inch, the 9.2-inch is barred from much employment on the score of weight, but the 7.5-inch is not, and we do not think there can be much question that a fire of six 7.5's from the *Queen's* broadside would match even the two 9.2's and five 6-inch of the *King Edward*. This six 6-inch would certainly fail to do.

BEDFORD, ESSEX, LANCASTER, AND MONMOUTH.

These armored cruisers of the *County* class have been launched since the last report. A description of the class is given on page 40, General Information Series No. XX.

KING ALFRED.

The armored cruiser *King Alfred*, the last of the *Drake* class building, was launched from the works of Vickers, Sons, & Maxim, Limited, at Barrow, October 28, 1901. The others of this class are the *Drake*, *Good Hope*, and *Leviathan*.

The *King Alfred* resembles the *Powerful* and *Terrible*, the apparent differences being that she has no military tops, and the poop has been cut away to increase the weight available for armor and guns. The

speed has been increased to 23 knots; there are four more 6-inch R. F. guns, but as each individual gun is of greater power, and attains a higher rate of fire, the weight of projectiles which may be discharged per minute has been increased from about $6\frac{1}{4}$ tons in the *Powerful* to about 9 tons in the *King Alfred*, while the muzzle energy has been more than doubled. The *Powerful* is a protected-deck cruiser, with 6-inch casemates for her 6-inch R. F. guns, and similar protection for the bow and stern 9.2-inch guns. In the *King Alfred* the armor protection is most effective. The main and auxiliary machinery and boilers and the magazines are protected by a water-line belt 11 feet 6 inches deep, extending over half the vessel's length, and varying in thickness from 6 inches amidships to 4 inches at the ends. At the after end of this belt a 5-inch armored bulkhead is fitted; and 2-inch nickel-steel protective plating is fitted on the bows. Aft the screen bulkhead is a protective deck $2\frac{1}{2}$ inches thick, affording protection to the steering gear and after capstan, etc. Within the citadel two protective decks are worked, the upper being $1\frac{1}{2}$ inches thick, and the lower 1 inch thick. The 9.2-inch guns are protected by 6-inch barbettes, in addition to gun shields. The 6-inch guns are each inclosed in a separate casemate, these being formed of 5-inch hard-faced armor. The conning tower is of 12-inch armor, with an armored tube 7 inches thick, affording protection to the controlling gear, etc.

The main armament includes two 9.2-inch Vickers guns, the perfection of the mechanism and mounting of which enables a rate of fire of four aimed rounds per minute with 380-pound shot, developing a muzzle energy of 17,830 foot-tons. Besides the two 9.2-inch guns mounted as bow and stern chasers, the *King Alfred* has twelve 6-inch guns, which are mounted in a series of two-story casemates, four on either broadside, and these 6-inch guns have on trial fired eight aimed rounds per minute, the projectile being of 100-pound weight. Four of the 6-inch guns, as well as one of the 9.2-inch weapons and two 12-pounders, fire ahead in line with the keel, while the same number of guns can discharge astern, the total number of projectiles being thus 116, with an aggregate weight of 5,720 pounds per minute ahead or astern; while the broadside fire amounts to 11,190 pounds. There is also a large number of 12-pounder and machine guns.

The *King Alfred* is to maintain a speed of 23 knots. The propelling machinery consists of two sets of four-cylinder triple-expansion engines; each of the two sets is designed to develop 15,000 I. H. P., giving a combined I. H. P. of 30,000. Steam is supplied by water-tube boilers of the latest Belleville economizer type, working at a pressure of 300 pounds per square inch. Each set of engines is placed in a separate engine room, divided by a longitudinal water-tight bulkhead which extends the whole length of the engine room. Each engine room is in all respects similar to but entirely independent of the other. The

main engines are of the inverted type, supported on cast-iron columns at the back and inclined wrought-steel columns at the front. The sole plates or main bearing frames are of cast steel, strongly bolted together so as to form a stiff foundation for the engines. All the cylinders are fitted with separate liners and are steam-jacketed. The diameter of the high-pressure cylinder is $43\frac{1}{2}$ inches, that of the intermediate cylinders 71 inches, and that of the two low-pressure cylinders $81\frac{1}{2}$ inches, all having a stroke of 48 inches. The high-pressure cylinder is fitted with one piston valve of the inside type, the intermediate cylinder is fitted with two piston valves having adjustable packing rings, while the two low-pressure cylinders are fitted with double-ported flat slide valves having a special type of relief ring.

There are two air pumps on each engine, worked by levers in the usual manner from the main engines. The main condensers are four in number, of cast gun metal, having a collective cooling surface of 32,000 square feet. There are two condensers to each set of engines, one forward and one aft, bolted to the back columns and resting on a seat. At the after end of each engine room is placed an auxiliary condenser having a cooling surface of 1,830 square feet. Under each auxiliary condenser is placed a combined air and circulating pump. Water is circulated through the main condensers by four $24\frac{1}{2}$ -inch centrifugal circulating pumps, each driven by independent engines, having, in addition to the suctions from the sea, the usual bilge connections.

The boilers are placed in 4 separate compartments, there being in all 8 fire-rooms running athwartships. The forward group in each boiler room consists of a single row of boilers, and the after group in each are placed back to back. There are thus 43 boilers with economizers, viz: Five boilers having 10 elements, with 8 element economizers; 28 boilers having 9 elements, with 7 element economizers; and 10 boilers having 8 elements, with 6 element economizers.

The other auxiliary machinery in the engine rooms comprises 4 electric light engines and dynamos, 2 steering engines, 2 reversing engines, 2 turning engines, 2 hot-well pumps, 4 fire and bilge pumps, 1 drain-tank pump, 1 latrine pump, 4 feed and brine pumps, 2 circulating and fresh-air pumps, 4 sets of evaporators, 2 distilling condensers, 2 ventilating fans and engines. In the boiler rooms are 8 Weir's feed pumps, 6 air-blowing engines for supplying the furnaces with small jets of air under a pressure of 15 pounds per square inch, 16 forced-draft fans with open double-acting steam engines, and 8 double-cylinder ash-hoist engines. In the outside machinery space are 2 coal-hoisting engines, 2 air-compressing engines and pumps, and 4 air reservoirs with valves complete, 1 ice-making machine, 1 workshop engine, and 1 hydraulic pumping engine.

The length of the *King Alfred* is 500 feet; width, 71 feet; and when

in fighting trim she will displace 14,100 tons, the draft then being 26 feet. The vessel carries 2,500 tons of fuel in her bunkers, and will therefore be able to steam at a cruising speed of 14 knots for 12,500 sea miles—equal to a voyage from Portsmouth to Melbourne—without renewing her fuel supply.

As launched the vessel is in a forward state; all her side armor with the 2-inch nickel steel had been built into the hull, and the after barbette and the casemates on the main deck constructed. The launching weight was 8,070 tons.

MOORHEX.

This shallow-draft gunboat, a sister ship to the *Teal*, was launched by Yarrow & Co., at Poplar, August 13, 1901. A description of these gunboats is given on page 53, General Information Series No. XX.

NO. 108.

This 25-knot torpedo boat, the last of a group of four built at Chiswick, was laid down September 5, 1900, and launched August 30, 1901.

VELOX.

This torpedo-boat destroyer, designed especially for steam turbine machinery, has been built by Hawthorn, Leslie & Co., at their Hebburn yard on the Tyne, the machinery having been furnished by the Parsons Company. It is understood that this vessel has not been built to the order of any Government. Her dimensions are: Length, 210 feet; beam, 21 feet; molded depth, 12 feet 6 inches. Special attention has been paid to the conditions necessary to secure longitudinal strength. The boilers are of the Yarrow type, and have been made by Messrs. Hawthorn.

The main propelling machinery consists of two independent sets of Parsons turbine engines, one high-pressure engine and one low-pressure engine being on each side of the vessel. This gives four turbines, each of which has its own line of shafting, and as each shaft carries two propellers, there are eight propellers in all. The high-pressure turbines drive the outer shafts and the low-pressure turbines the inner ones. For going astern reversing turbines are incorporated in the exhaust casing of each of the low-pressure cylinders. A novel feature in this vessel is the introduction of ordinary reciprocating engines fitted in conjunction with steam turbines. These engines are of the triple compound type, and are coupled direct to the main turbines and work in conjunction with them. They take steam directly from the boilers, and exhaust through the high-pressure turbine, the exhaust from the latter passing in turn through the low-pressure turbine, and from thence to the condensers. These reciprocating engines are for use at cruising speeds, when low power is only needed, and are therefore of compara-

tively small size. All steam engines, including the steam turbine, do not show high efficiency when they are working much below the power for which they are designed, and as destroyers very seldom run at their top speed they are apt to be wasteful of fuel during the greater part of their steaming. The new arrangement which Mr. Parsons has introduced should therefore be a distinct advantage. When higher powers than those needed for absolute cruising speeds under ordinary conditions are needed, steam will be admitted to the turbines direct from the boilers, and when the highest speed is needed, which would bring the rate of revolution beyond that permissible with reciprocating engines, steam will be entirely cut off from the latter, they being at the same time thrown out of gear, and the steam turbines alone would be used.

SUBMARINE BOATS.

Of the five submarine boats building at Barrow for the English navy, No. 1 was launched October 2, 1901; No. 2, February 21, 1902, and Nos. 3, 4, and 5, May 9, May 23, and June 10, 1902, respectively. These are of the Holland type and are described on page 55, General Information Series No. XX.

A new type of submarine has been ordered by the Admiralty from Messrs. Vickers, Son & Maxim, Barrow. The Admiralty originally gave the order to Barrow for five out of six submarines, and now the sixth is also to be built there. She is to be 100 feet long—37 feet longer than the other five—and will embrace some new departures in design and construction based on the experiments already made.

FRANCE.

PATRIÉ AND RÉPUBLIQUE.

The keel of the *République* was laid at Brest, December 2, 1901. All the frames are now in place and also a part of the side plating. The *Patrié* will be constructed at La Seyne.

A description of these new battleships is given on page 57, General Information Series No. XX.

AMIRAL AUBE AND CONDÉ.

These armored cruisers of 10,000 tons, the former laid down at St. Nazaire August 9, 1901, and the latter at Lorient March 20, 1901, were launched May 9, 1902, and March 12, 1902, respectively. They are the last of a class of five vessels, the *Gloire*, *Marseillaise*, and *Sully*, having been launched in 1900–1901. A full description of these vessels is given on pages 57–60, General Information Series No. XX.

LEON GAMBETTA.

This armored cruiser was laid down at Brest, January 15, 1901, and was launched October 26, 1901.

Her dimensions are: Length, 486.7 feet; beam, 70.2 feet; displacement, 12,600 tons; draft, 27 feet. Armament: Four 7.64-inch guns; sixteen 6.5-inch guns; twenty-two 3-pounders; and two 1-pounders. Of the sixteen guns of medium caliber, twelve are in pairs in six turrets and the other four are in armored redoubts. The ship will have five torpedo tubes, of which two will be submerged.

The three independent engines should develop 27,500 I. H. P., and give a speed of 22 knots. There will be 28 Niclausse water-tube boilers in four separate compartments. The grate and heating surfaces are, respectively, 1,658 and 55,682 square feet. The tubes have a diameter of 3.3 inches and are 7.7 feet long. Special arrangements permit of the combined or separate use of coal and oil as fuel. The bunkers will hold about 2,100 tons of coal and 100 tons of petroleum, which is estimated to give a radius of action at 10 knots of 12,000 miles. This estimate is probably too large, as it would give a steaming capacity of about 6 knots per ton of coal, which is seldom realized in ships of this size, 4 knots per ton being more nearly correct in practice.

Besides her main engines, there will be the usual auxiliary machinery for turrets, ammunition hoists, torpedoes, steering, anchors, boat hoisting, ventilation, flushing and fire systems, evaporators, and freeing pumps. The launching weight of the vessel was 3,480 tons.

She will be fitted as a flagship, and will carry 19 boats. The complement will consist of 38 officers and 695 men.

DUPETIT-THOUARS.

This armored cruiser of 9,517 tons was laid down at Toulon, April 17, 1899, and was launched July 5, 1901. Her principal dimensions are: Length, 452.7 feet; beam, 63.5 feet; draft, 24.5 feet. She has vertical triple-expansion engines, water-tube boilers, and three propellers, and is to have a speed of 21 knots. The ordinary coal storage is 1,020 tons, giving a radius of action of 6,500 miles at 10 knots and 1,230 miles at full speed. It is possible, however, to carry 1,600 tons, giving a radius of action of 10,300 miles at 10 knots and 1,920 miles at full speed. Protection is given by an armored belt 6.2 inches thick, turret armor 8.6 inches thick, and an armored deck 1.5 inches thick. Her armament includes two 7.6-inch guns, eight 6.4-inch guns, four 3.9-inch guns, sixteen 1.8-inch guns, and six 1.4-inch guns. She also has two submerged torpedo tubes. Her complement is fixed at 32 officers and 578 men.

RAPIERE AND FLAMBERGE.

These torpedo-boat destroyers of 311 tons displacement were launched at Rochefort, the former July 16, 1901, and the latter October 28, 1901. Their principal dimensions are: Length, 183.7 feet; beam, 19 feet; draft, 7.2 feet; estimated speed, 27 knots, with 5,200 I. H. P.

BOURRASQUE.

This seagoing torpedo boat, laid down at Havre June 28, 1900, was launched August 31, 1901. The principal characteristics of the vessel are: Length, 147.6 feet; beam at water line, 15.7 feet; greatest beam, 16.6 feet; mean draft, 4.9 feet; draft under screw, 8.1 feet; displacement of hull (without load), 161.2 tons; maximum H. P., 4,600; contract speed, 29 to 30 knots.

TRITON, ESPADON, AND SILURE.

These submarine torpedo boats have been launched at Cherbourg, the *Triton* July 13, the *Espadon* August 31, and the *Silure* October 29, 1901. These are the last of the series of five, of which the others are the *Narval* (type) and the *Sirene*. The principal characteristics of these boats are: Length, 111.5 feet; beam, 12.3 feet; draft, when on the surface, 5.2 feet; displacement, 106 tons; displacement below water, 202 tons; estimated speed, 12 knots. There are four torpedo-launching apparatus. The crew consists of 11 men.

NOS. 253, 254, 255, 256, AND 257.

These first-class torpedo boats, built at Havre, have been launched since the last report. They have a displacement of 90 tons and a speed of 24 knots. Their principal dimensions are: Length, 121.3 feet; beam, 14 feet; draft, 8.9 feet. The armament consists of two 37-millimeter guns, and there are two torpedo tubes, one in the bow compartment, passing through the stem, and the other on deck abaft the engine-room hatch.

NOS. 259, 260, AND 264.

These first-class torpedo boats, of the same type as those built at Havre, have been launched at Bordeaux since the last report.

GERMANY.

WITTELSBACH CLASS.

The first-class battleship *Schwaben* was launched at Wilhelmshaven, August 19, 1901, and the *Mecklenburg* at Stettin, November 9, 1901. These vessels were known previous to launching as battleships "G" and "F," a description of which is given on page 65 of General Information Series No. XX.

PRINCE FRIEDRICH KARL.

The armored cruiser *Ersatz König Wilhelm* was launched at Blohm and Voss's shipyard, Hamburg, June 21, 1902, and named *Prince Friedrich Karl*. She is a sister ship of the *Prince Adalbert*. Her principal dimensions are: Length, 393.7 feet; beam, 64.3 feet; draft, 24 feet; displacement, 8,868 tons. Her armament consists of the following R. F. guns: Four 8.27-inch, ten 5.9-inch, twelve 3.46-inch, and fourteen machine guns. She has four torpedo launching tubes. Thickness of armor: Belt, 3.94 inches; deck, 1.96 inches; turret, 5.91

inches. She has triple screws driven by engines developing 16,000 I. H. P., and is designed for a maximum speed of 21 knots.

FRAUENLOB AND ARCONA.

The small cruiser known as "G" was launched at the Weser shipyard in Bremen, March 22, 1902, and named *Frauenlob*. Her principal dimensions are: Length between perpendiculars, 328 feet; beam, 40.35 feet; draft, 16.4 feet; and displacement, 2,700 tons. Her engines are to develop 8,000 H. P. and give a speed of 22 knots. The armament consists of ten 4.13-inch R. F. guns, twelve of 37 millimeters, and several 8-millimeter guns. There are to be two submerged torpedo tubes. The ship has twin screws, driven by two triple-expansion three-cylinder engines. There are nine water-tube boilers of the Thornycroft-Schultz type. The auxiliary machinery includes three large dynamos for electric lighting and running electric motors, for ventilation, ammunition hoists, steering gear, capstan, pumps, etc. Coal capacity, 600 tons, and steaming radius, 6,000 sea miles. Complement, 250 men.

The *Arcona* (Ex. H), a sister ship of the *Frauenlob*, and building at the same yard, was launched April 22, 1902.

TORPEDO-BOAT DESTROYERS.

Of the two divisions of torpedo-boat destroyers laid down in 1901, S-102 to S-107 at Elbing and G-108 to G-113 at the Germania Works, Kiel, S-106 was launched September 7, 1901, and S-107 October 17, G-108 and G-109 September 7, 1901, G-110 April 2, 1902, and G-111 June 19, 1902. The principal characteristics of these boats are as follows: Length, 206.7 feet; beam, 22.9 feet; draft, 8.85 feet; displacement, 350 tons; speed, 27 knots; I. H. P., 5,400; coal capacity, 100 tons; three above-water torpedo tubes.

PRINZ ADALBERT.

A German writer in the *Ueberall Armee und Marine* makes the following very instructive comparison between the latest German, French, and English armored cruisers:

	Launched.	Displacement.	Indicated horse-power.	Maximum speed.	Coal capacity.	Armament. ^a	Torpedo tubes.
		<i>Tons.</i>		<i>Knots.</i>	<i>Tons.</i>		
Prinz Adalbert	1901	9,048	16,500	21	1,500	Four 8.27-in., ten 5.9-in., twelve 3.46-in., ten 37 mm.	4
Cressy	1899	12,192	21,000	21	1,625	Two 9.06-in., twelve 6-in., fourteen 2.95-in., three 47 mm.	2
Montcalm	1900	9,517	19,600	21	1,600	Two 7.64-in., eight 6.5-in., four 3.94-in., sixteen 47 mm., six 37 mm.	2

^a All rapid fire.

The *Prinz Adalbert* has a complete belt of armor 3.94 to 3.15 inches thick. The citadel, three-fifths of her length, is 3.94-inch armor, closed forward and aft by inclined bulkheads.

The *Cressy* has a belt of armor over three-fourths of her length, which is rather heavier than that of the *Prinz Adalbert*. The guns are mounted separately and locally armored.

The *Montcalm* has a complete armor belt, and the greater part above the belt is armored.

The *Prinz Adalbert* has the smallest displacement, which thus accounts for the difference in coal capacity.

The *Prinz Adalbert* is the best armed, since there is but little difference in the penetrative power of the 8.27-inch and 9.06-inch R. F. guns.

ITALY.

VITTORIO EMANUELE.

It is reported that for her secondary battery this battleship will carry twelve 4-inch R. F. guns instead of twelve 12-pounders.

BENEDETTO BRIN.

This first-class battleship was laid down at Castellamare in February, 1899, and launched November 7, 1901. She is a sister ship of the *Regina Margherita*, a description of which is given on page 73 of General Information Series No. XX. The latest reports state that she is to be fitted with Belleville boilers instead of Niclausse boilers. The armor is all of domestic manufacture, furnished by the Terni Steel Works.

FRANCESCO FERRUCCIO.

The armored cruiser *Francesco Ferruccio*, a sister ship of the *Gariibaldi* and *Varese*, was launched at Venice April 23, 1902. This ship was designed by E. Masdea, chief of the technical department in the Italian ministry of marine.

Her dimensions are: Length, 363.28 feet; beam, 61.37 feet; draft, full load, 23.39 feet; displacement, 7,460 tons. The weights are distributed as follows:

	Tons.
Hull	3, 625
Armor.....	1, 330
Armament, including torpedoes	850
Machinery and boilers.....	1, 055
Coal.....	600
Total	7, 460

The hull is built of Italian steel. She has a partial double bottom, one armored deck, and three decks above, and is divided into numerous water-tight compartments. She has a complete armor belt extend-

ing from outside of the armored deck and terminating in an armored citadel above. The armor is of Terni nickel-steel. Amidships along the belt and sides it is 5.9 inches thick, diminishing in thickness at the extremities. The athwartship bulkheads forward and abaft the citadel are 4.7 inches thick. The machinery, steering gear, etc., are below the protective deck.

The armament consists of one 10-inch gun in forward armored turret, two 8-inch guns in after turret, fourteen 6-inch guns—ten in citadel, four with shields—ten 2.75-inch guns, and six 47-millimeter guns. The guns were made by Armstrong at Pozzuoli. There are two submerged torpedo tubes.

The engines are triple-expansion, built by Hawthorn Guppy, at Naples, driving twin screws. She has 24 Niclausse water-tube boilers. Of the six compartments the two forward ones contain 4 and 8 boilers, respectively, as do also the two after ones, while the machinery occupies the two middle compartments, separated by longitudinal bulkheads.

The engines develop 13,500 I. H. P., and give a speed of 20 knots. There are 20 coal bunkers, having a capacity of 600 tons.

The ship carries 11 boats, two of which are steam launches.

The electric machines develop 132 kilowatts, used for lighting, ventilation, training turrets, hoisting ammunition, and for auxiliaries generally.

The centrifugal pump discharges 2,000 tons of water per hour, and the Thirio suction pump 400 tons per hour.

The hull was finished when the ship was launched.

The armament of this vessel will probably be delayed on account of the guns originally intended for her having been sold to Ansaldo for the two new Argentina ships that the latter company has contracted for.

TURBINE.

This torpedo-boat destroyer, built by Pattison, at Naples, was launched November 21, 1901. Her principal characteristics are: Length, 210 feet; beam, 19.5 feet; draft, aft, 7.5 feet; displacement, 350 tons; I. H. P., 6,000; coal supply, 80 tons. It has three water-tube boilers and two triple-expansion four-cylinder engines. The armament consists of one 3-inch R. F. gun, five 2.25-inch R. F. guns, and two deck torpedo tubes.

JAPAN.

NIITAKA AND TSUSHIMA.

The latest report is that these second-class protected cruisers are to be entirely constructed of domestic material. This includes armor, machinery, ammunition, and guns.

AKATSUKI AND KASUMI.

These torpedo-boat destroyers, built by Yarrow, at Poplar, have been launched, the former November 13, 1901, and the latter January 23, 1902. Their principal dimensions are: Length between perpendiculars, 220 feet 3 inches; beam, 20 feet 6 inches; mean draft, 5 feet 4 inches; displacement, 325 tons; estimated I. H. P., 6,000; speed, 31 knots; bunker capacity, 90 tons; armament, one 12-pounder and five 6-pounder R. F. guns, and two torpedo tubes.

ASASHIO AND SHIRAKUMO.

These torpedo-boat destroyers, built by Thornycroft, at Chiswick, have been launched, the former January 10, 1902, and the latter October 1, 1901. Their principal dimensions are: Length between perpendiculars, 216 feet 8 inches; beam, 20 feet 9 inches; mean draft, 6 feet; displacement, 333 tons; estimated I. H. P., 7,000; speed, 31 knots; bunker capacity, 90 tons. The armament is the same as that of the *Akatsuki* and *Kasumi*. The *Shirakumo* was built in seven months.

SWEDEN.

AERAN, TAPPERHETEN, AND WASA.

These armored coast-defense vessels have been launched, the *Aeran* at Gotaborg, August, 1901; the *Tapperheten* at Malmo, October, 1901, and the *Wasa* at Stockholm, September, 1901.

The general dimensions are: Length, 288.7 feet; beam, 49.21 feet; draft, 16.4 feet; displacement, 3,650 tons.

Their armament consists of two 8.27-inch guns, six 5.91-inch R. F. guns, ten 57-millimeter R. F. guns, and two 37-millimeter R. F. guns. There are two submerged 45-centimeter torpedo tubes.

The gun positions have an armor protection of from 7.48 inches to 5.12 inches in thickness, and there is an armored deck 1.89 inches thick.

PORTUGAL.

TEJO.

The high-sea torpedo boat *Tejo*, of 530 tons, was launched at the arsenal in Lisbon October 28, 1901. Her principal characteristics are: I. H. P., 7,000; speed, 25 knots; armament, one 2.95-inch gun and six 47-millimeter R. F. guns, and three torpedo tubes.

RUSSIA.

BORODINO AND IMPERATOR ALEXANDER III.

These first-class battleships, of 13,600 tons, have been launched, the former September 8, 1901, at the New Admiralty, and the latter August 2, 1901, at the Baltic Works, St. Petersburg. A description of these vessels is given on page 90, General Information Series No. XX.

KNIAZ SUVAROFF.

This new battleship of the *Borodino* class was laid down September 8, 1901, at the Baltic Works. She was to have been built at Galernii Island, where she was laid down early in June, 1901, but on account of the fire that practically destroyed the plant at that yard she was transferred to the Baltic Works.

OKEAN.

This combined training ship and collier was laid down at Howaldt's shipyard, Kiel, June 10, 1901, and was launched February 16, 1902. She is to be used to train 750 machinists and firemen annually, and for that reason is fitted with the most modern machinery and with various types of boilers. Her dimensions are: Length over all, 490 feet; length between perpendiculars, 470 feet; beam, 57 feet; draft, full load, 25 feet; load displacement, 11,900 tons. The main engines are two vertical triple expansion, each with four cylinders, and are to give 11,000 I. H. P. Every kind of modern auxiliary engine in use in the navy will be installed on board. All exhaust steam from main and auxiliary engines must be conveyed directly to the boilers, and in consequence the steam whistle and steam siren are to be replaced by pneumatic signals. There will be, however, a reserve steam whistle.

One group of boilers is to be of six Belleville and six Niclausse; the other group, two Shulz-Thornycroft and three Yarrow small tube. The total heating surface of all boilers is 34,500 square feet. She is to have a speed of 18 knots under normal draft. Government goods are to be transported, for which the ship has four cargo rooms of 180,000 cubic feet and can carry 4,000 tons of cargo. The coal bunker capacity is for 1,600 tons. There are eight steam winches with cranes and two Temperly transporters.

There are quarters for 25 officers and 700 men, a roomy machine shop, two bathrooms, steam galley, bakery, and refrigerating room. There are 14 boats, two with steam and five with other mechanical motors.

KAMCHATKA.

This seagoing Government collier is building at the New Admiralty Works, St. Petersburg. She will be of 7,200 tons and have a draft of 22 feet.

There are to be two triple-expansion engines, which are to work with a pressure of 150 pounds and give 125 revolutions per minute. They are to develop not less than 2,800 I. H. P. The dimensions of the cylinders are: High pressure, 20.08 inches; intermediate pressure, 31.89 inches; low pressure, 50 inches; and piston stroke, 33.07 inches.

The propellers are to be made of manganese bronze, and to have a diameter of 13 feet 6 inches, with a mean pitch of 12 feet.

The boilers are of the Belleville type and are being constructed at

the Franco-Russian Works. They must not consume more than 2.5 pounds of coal to the I. H. P. per hour developed by the engines, the working pressure in the boilers being 240 pounds per square inch, and the heating surface 9,388 square feet.

Condensers: Cooling surface, 4,200 square feet; auxiliary condensers of 700 square feet each will be supplied.

There are two evaporators, with a capacity of 30 tons of water for use in the boilers; and a special apparatus for making drinking water, with a capacity of 10 tons, will be provided.

KEFAL AND LOSOS.

These torpedo-boat destroyers of the *Forel* group of five, building in France, have been launched at Toulon, the *Kefal* November 28, 1901, and the *Losos* March 12, 1902. A description of these destroyers is given on page 100, General Information Series No. XX.

BAKLAN.

It is reported that this torpedo-boat destroyer, of 240 tons, which is described on page 99, General Information Series No. XX, was shipped as freight to the east Asiatic coast and launched at Port Arthur on August 12, 1901.

AKULA, BUICHOK, MAKREL, AND NALIM.

These torpedo-boat destroyers, of 350 tons displacement, have been launched at the Newski Works, St. Petersburg, the *Akula* and *Buichok* August 24, 1901, and the *Makrel* and *Nalim* October 12, 1901. They are designed for 26 knots, with 4,200 I. H. P.

SUBMARINE BOAT.

The Russian submarine boat that is being constructed on the plans of Engineer Kuteinikoff and Lieutenant Kolbasieff differs from all existing types. It consists of nine sections which are connected together by bolts, and are capable of being taken to pieces. The length is 50 feet, the breadth 4 feet, and the boat will have a displacement of 20 tons. The three middle sections will contain the machinery. There will be six screws actuated by electricity, and accumulators on the Bari system will be placed in the three forward and the three after sections. These same sections will be capable of being filled with water for the purpose of sinking the boat. The first and ninth sections will have fixed wing-like appendages to give direction to the boat. The armament will consist of two torpedoes placed fore and aft for the length of three sections. The torpedoes will also be controllable from the boat. All sections are now finished. Three have been launched and under high-pressure tests have given excellent results.

SPAIN.

ESTREMADURA.

The armament for this cruiser of 2,030 tons displacement is to be furnished by Vickers, Sons & Maxim, and will consist of eight 4-inch R. F. guns of 50 calibers length, four 2.2 R. F. guns, two 37-millimeter, two Maxim machine guns, and two 3-inch boat guns.

SECTION III.

STEAM TRIALS.

ENGLAND.

RUSSELL.

The first-class battleship *Russell* returned to the Nore on April 19, 1902, on the completion of a thirty hours' coal-consumption trial at one-fifth power. The results were as follows: Draft of water, forward, 26 feet, aft, 27 feet 3 inches; steam in boilers, 211 pounds; revolutions per minute, starboard, 74.8, port, 74.5; vacuum in condensers, starboard, 27, port, 27.3; mean I. H. P., high, starboard 653, port 755; intermediate, starboard 579, port 549; forward, low, starboard 298, port 354; aft, low, starboard 295, port 285; total, starboard 1,825, port 1,943; grand total, 3,768. Speed, 12.1 knots. The coal consumption was 2.4 pounds per I. H. P. per hour.

On April 22 she returned to the Nore after running a thirty hours' steam trial with her engines working at 13,500 horsepower, which is three-fourths her full power. The results of the trial were satisfactory, the speed being 18 knots, with a coal consumption of 2.14 pounds per I. H. P. per hour.

The results of her eight hours' full-power trial were as follows: Steam pressure in boilers, 294 pounds; vacuum, starboard engine 25 inches, port engine 25.2 inches; revolutions, starboard engine 123.3, port engine 123.5; I. H. P., starboard engine, 9,033, port engine, 9,196; total I. H. P., 18,229; coal consumption per horsepower per hour, 2.09 pounds; speed, 19.3 knots.

LONDON.

The first-class battleship *London* returned to Spithead on January 15, 1902, after a thirty hours' coal-consumption trial at one-fifth her power. She drew 26 feet 3 inches forward and 27 feet aft, and had a steam pressure of 248 pounds in her boilers. The vacuum was 27.6 inches starboard and 27.3 inches port, and the revolutions were 65.68 starboard and 65.26 port, the I. H. P. being 3,237, and the speed 11½ knots. The coal consumption was 1.81 pounds per I. H. P. per hour. She left on the 17th for a thirty hours' trial, which, however, had to be abandoned, as the bearings became overheated.

On February 3 she left Portsmouth for her thirty hours' trial at four-fifths power. She returned the next day at the end of a twenty-six hours' run, the trial, which was satisfactory, having to be curtailed on account of thick weather. The vessel drew 26 feet 3 inches forward and 27 feet 3 inches aft, and, with 262 pounds of steam in her boilers, the revolutions were 101.4 starboard and 100.7 port, producing a mean I. H. P. of 11,718 and a speed of 16.4 knots. The coal consumption was 1.8 pounds per unit of horsepower per hour.

The *London* completed her eight hours' full-power trial on February 8. The engines and Belleville boilers worked most satisfactorily. She averaged 15,264 horsepower, which gave her a speed of 18 knots on a coal consumption of 1.97 pounds per horsepower per hour.

VENERABLE.

This first-class battleship returned to Chatham May 29, 1902, on the conclusion of her machinery trials, which were satisfactorily completed in the short period of eight days. This time would have been shortened had it not been for a slight mishap to the machinery just before the eight hours' full-power trial was to be started, which caused one day's delay. The vessel left Chatham on May 20, and had a preliminary trial on the following day. On May 22 she left the Nore for a thirty hours' coal-consumption trial at one-fifth power (3,000 I. H. P.). The draft of water was 26 feet 7 inches forward and 27 feet 1 inch aft. With a steam pressure in the boilers of 225 pounds per square inch, and the engines working at 65.3 revolutions starboard and 66.7 revolutions port, a speed of 11.45 knots was maintained. The vacuum in the condensers was 27.5 inches starboard and 27.1 inches port. The mean I. H. P. was 1,472 starboard and 1,610 port, giving a total of 3,082. The coal consumption was 2.01 pounds per I. H. P. per hour. The second thirty hours' coal-consumption trial was at four-fifths power (11,500 I. H. P.) and took place on May 24 and 25. The draft of water was 26 feet 3 inches forward and 27 feet 1 inch aft. The steam pressure was 26 pounds per square inch and the revolutions 101.1 starboard and 102.5 port, while the vacuum in the condensers was 27.7 starboard and 27.5 port. The speed by log was 16.8 knots. The starboard engine developed 5,590 I. H. P. and the port engine 5,774, a total of 11,364. The coal consumption was 1.95 pounds per I. H. P. per hour. The details of the eight hours' full-power trial are as follows:

Draft of water, forward, 26 feet 4 inches, aft, 27 feet 1 inch; speed of ship, 18.3 knots; steam pressure in boilers, 294 pounds per square inch; air pressure in fire-rooms, 0.1 inch; vacuum in condensers, starboard 26.8 inches, port 27 inches; revolutions, starboard 111.1, port 112.4; mean I. H. P., starboard 7,600, port 7,745, total, 15,345. The coal consumption was 2.145 pounds per I. H. P. per hour.

EXMOUTH.

This first-class battleship completed her trials at Plymouth on June 18, 1902. The results of the thirty hours' trial at four-fifths power were:

Speed, 18 knots per hour; vacuum in condensers, 27.6 starboard and 27 port; revolutions per minute, 113.2 starboard and 112.8 port; horsepower, 6,934 starboard and 6,840 port; total horsepower, 13,774; consumption of coal per I. H. P. per hour, 1.95 pounds; total consumption, 806,648 pounds.

At the eight hours' full-power trial the mean results were: Vacuum, 26.8; revolutions, 126.6; I. H. P., 18,346; speed, 19.05 knots; consumption of coal per I. H. P. per hour, 2.13 pounds.

BACCHANTE.

The first-class armored cruiser *Bacchante* left Chatham November 25, 1901, and, after a preliminary trial, started, on the 26th, on a thirty hours' coal consumption trial at 4,500 I. H. P. The details are as follows: Draft of water forward 26 feet 4 inches, aft 26 feet 10 inches; speed of ship, 13.6 knots, by log; steam pressure in boilers, 213 pounds per square inch; vacuum in condensers starboard 27, port 27; revolutions per minute, starboard 75, port 75.4; mean I. H. P., starboard 2,335, port 2,289, grand total 4,624. The consumption of coal was 250,345 pounds, which works out 1.8 pounds per I. H. P. per hour. The second and more important trial commenced on the 29th, when the ship left the Nore for a thirty hours' test at 16,000 I. H. P. The weather was moderately good, but, after running for twenty-nine and three-quarters hours, the vessel ran into a thick bank of fog, and it was decided to stop the trial, the results being taken for twenty-nine hours. These were as follows: Draft of water forward 25 feet 9 inches, aft 26 feet 9 inches; speed of ship, 20.6 knots; steam pressure in boilers, 256 pounds per square inch; vacuum in condensers, starboard 26.7, port 27.5; revolutions per minute, starboard 112.2, port 113.2; total I. H. P. 16,445. The coal consumption was 837,168 pounds, which represents 1.75 pounds per I. H. P. per hour. The trials were considered satisfactory in every respect.

The first full power trial, 21,000 I. H. P., did not succeed, owing to heated bearings, and the vessel had to return to Sheerness to coal and remedy defects. She left on December 6 for a preliminary trial, which was of a satisfactory character, and before anchoring for the night she carried out anchor trials. Starting on December 7, the machinery was found to be working well, and the eight hours' full power trial was commenced. Throughout the vessel behaved admirably, while the machinery worked smoothly, and there was an absence of priming. The results were as follows: Draft of water forward

25 feet 9 inches, aft 26 feet 9 inches; speed of ship, 21.7 knots; steam pressure in boilers, 285 pounds per square inch; vacuum in condensers, starboard 26.5, port 26.5; revolutions per minute, starboard 119.5, port 120.4; mean I. H. P., starboard 10,812, port 10,708; grand total 21,520. The coal consumption was 292,800 pounds, which represents 1.7 pounds per I. H. P. per hour, as against 1.75 pounds at 16,000 I. H. P.

HOGUE.

The first-class armored cruiser *Hogue* left Plymouth on December 10 for a thirty hours' steam trial in the Channel at a mean I. H. P. of 4,500. With engines developing 4,738 horsepower, the mean indicated speed was 13 knots per hour and the coal consumption was 2.09 pounds per hour per I. H. P. The steam at engines was 179 pounds; the revolutions were—starboard 74.6, port 74.8.

On December 13 she left Plymouth for her thirty hours' contractors' steam trial at four-fifths power, which was attended with most satisfactory results in spite of rough weather encountered. A total horsepower of 16,456 was maintained, producing an average speed of 20.15 knots. The mean results were: Steam in engines, starboard 220 pounds, port 226 pounds; vacuum, starboard 25.6 inches, port 25.5 inches; revolutions, starboard 113.1, port 111.6; pressure in cylinders, high, starboard 102.5, port 104.3; intermediate, starboard 34.7, port 34.8; low (forward), starboard 13.3, port, 13.8; low (aft), starboard 13.5, port 15.3; I. H. P., starboard 8,139, port 8,137. The coal consumption per I. H. P. per hour was 2.05 pounds.

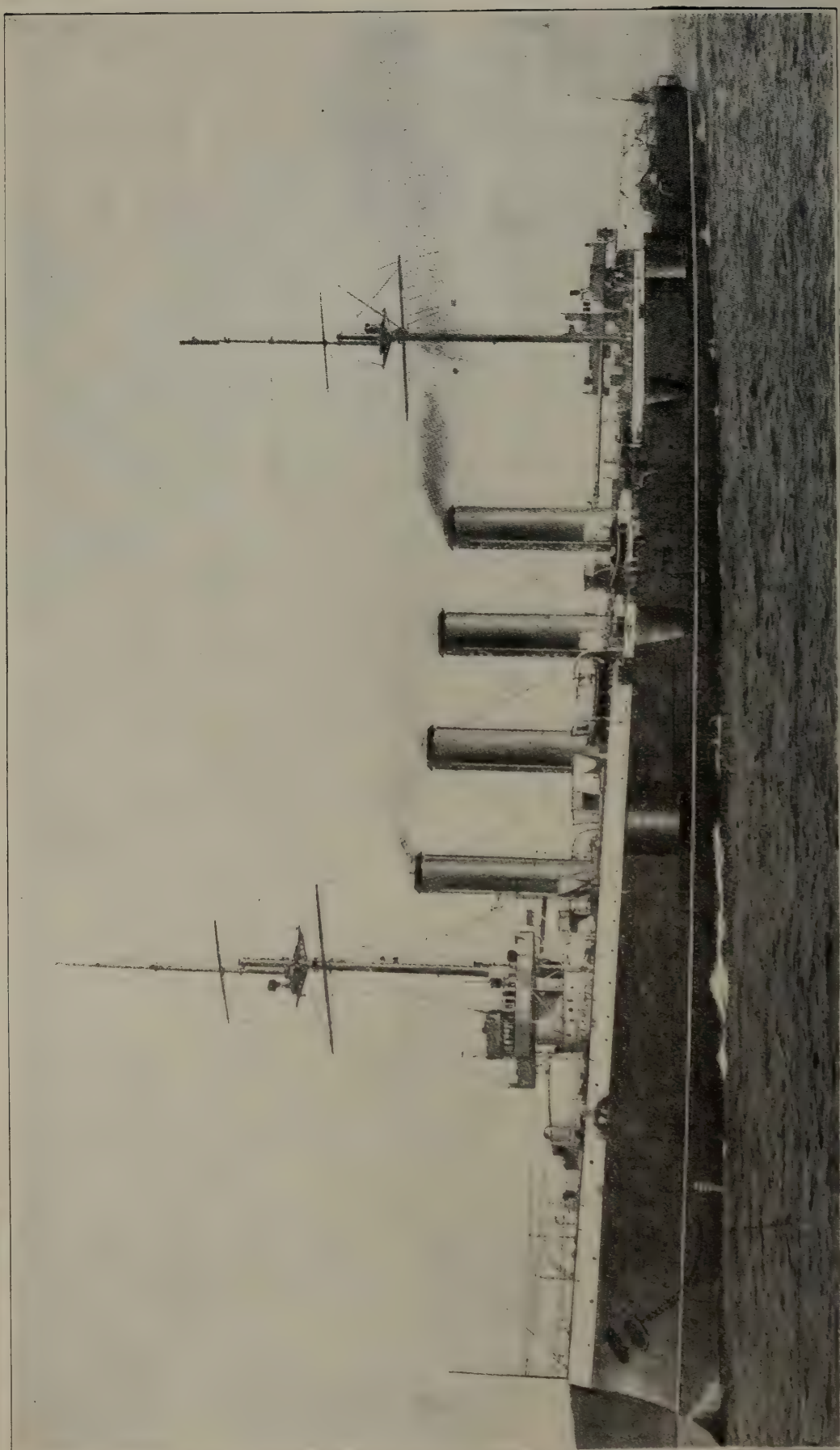
She returned to Plymouth on December 17 for her full power trial, which was highly successful. With an I. H. P. of 22,065, she attained a mean speed of 22 knots. The coal consumption was 2.5 pounds per I. H. P. per hour.

BEDFORD.

The first-class armored cruiser *Bedford* completed her trials at Plymouth on June 20, 1902. At one-fifth full power the mean results for thirty hours were:

Steam at engines, 238 pounds; in boilers, 255 pounds; vacuum, starboard 26.8 inches, port 26.3 inches; revolutions, starboard 85, port 84; I. H. P., starboard 2,250, port 2,272 (total, 4,522); speed, 14.92 knots. The coal consumption was 1.91 pounds per I. H. P. per hour.

At four-fifths full power the mean results were: Steam in boilers, 246 pounds; at engines, 222 pounds; vacuum, starboard 25.6 inches, port 25.7 inches; revolutions, starboard 128.6, port 127.1; I. H. P., starboard 7,952, port 8,053 (total, 16,005); air pressure, 0.26 of an inch; speed, 21.2 knots. On this trial the *Bedford* consumed coal at the rate of 1.97 pounds per I. H. P. per hour.



GOOD HOPE, ENGLISH ARMORED CRUISER, 14,100 TONS.

The last of the series was an eight hours' trial at full power; and although the engines worked splendidly throughout, the estimated speed of 23 knots was not maintained, the mean speed recorded being 22.7 knots. This result was all the more disappointing because the engines were driven at considerably above the power that was calculated as their maximum when designed, viz, 22,000. The mean results of the trial were: Steam in boilers, 285 pounds; at engines, 228 pounds; air pressure in fire rooms, 0.32 of an inch; vacuum, starboard 26 inches, port 25.5 inches; revolutions, starboard 149.2, port 101; I. H. P., starboard 11,286, port 11,171 (total, 22,457). The coal consumed was at the rate of 2.12 pounds per I. H. P. per hour.

GOOD HOPE.

The first-class armored cruiser *Good Hope* began her trials February 18, 1902. The first, at one-fifth full power, was of thirty hours' duration, and was to determine the radius of action for the coal supply carried—2,590 tons—and as on this trial the rate of coal consumption was 1.87 pounds per I. H. P. per hour, the ship may steam at 14 knots' speed for 7,000 nautical miles. On the second trial, also of thirty hours' duration, the test was very severe. No warship has ever steamed for so long a time at this power—22,703 I. H. P.; but everything went splendidly, and the coal consumption as shown in the table, worked out to 1.83 pounds per I. H. P. per hour. At this power four runs were made over the deep-sea course between Rame Head and Dodman Point, when it was found that the mean speed was 22.09 knots, and this agreed with the observations of Captain Wilson, who was in command during the whole run, when the vessel went 60 miles west of the Scilly Isles.

On the eight hours' full power run the power developed was 31,071 I. H. P., which is equal to 12.23 I. H. P. per ton of all machinery and 47.6 I. H. P. per ton of boilers, results far in excess of those realized in ships with cylindrical boilers, while in Atlantic liners of corresponding speed the power per unit of weight of all machinery is only 6 I. H. P. per ton. The speed on this trial was 23.05 knots. This is the mean of mean result of five runs over the deep-sea course in a heavy swell, which was not conducive to high steaming. The power and speed anticipated was 30,000 I. H. P. and 23 knots. The coal consumption on this run was 1.92 pounds per I. H. P. per hour, and it should be noticed that all the water lost throughout all the trials was made in evaporators run by the exhaust steam from the 75 auxiliary engines on board the ship, thus effecting a great economy.

	First trial.	Second trial.	Third trial.
Duration.....hours.....	30	30	8
Steam pressure in boilers.....pounds.....	239	268	278
Vacuum:			
Starboard engine.....inches.....	25.5	26.5	26.5
Port engine.....do.....	26.6	27.25	27
Revolutions:			
Starboard engine.....	70.8	109	123.9
Port engine.....	71.4	110.7	126.1
Indicated horsepower:			
Starboard engine.....	3,069	11,325	15,361
Port engine.....	2,985	11,378	15,710
Indicated horsepower, collective.....	6,054	22,703	31,071
Coal consumption.....pounds.....	1.87	1.83	1.92
Speed of vessel.....knots.....	14.5	22.09	23.05

Immediately after the contract trials there was a series of long-distance runs at progressive speeds, the deep-sea course of 22 knots west of Plymouth Sound being traversed three times at about 18 knots and three times at about 20 knots. On the first of these sets the mean of mean speed was 18.10 knots, with the engines indicating 12,108 I. H. P., and on the second the result was 20.58 knots for 16,960 I. H. P. Having completed these runs, the vessel headed up the channel for Spithead, as the subsequent speed trials at low powers were to be made over the measured mile at Stokes Bay, and although it was a dark night with a driving southwest rain storm and by no means a smooth sea, a record trip for a warship was made, the time from outside Plymouth Breakwater to the Warner Lightship being slightly over six hours, giving a mean speed of nearly 20 knots. On the following day the *Good Hope* made four runs at 15 knots, 13 knots, and 10 knots' speed at Stokes Bay. It was found that 2,689 I. H. P. gave 10.6 knots, 5,096 I. H. P. resulted in a mean of mean speed of 13.63 knots being attained, while on the next series the average power was 7.953 I. H. P. and the speed 15.91 knots. There was also a very severe test of the steering machinery, which, with the anchor and capstan gear, was supplied by Messrs. Napier Brothers, of Glasgow. The ship was driven astern at 18 knots while the helm was kept at various degrees up to hard over, and the result was very satisfactory, the steering mechanism standing the test well. The ship returned to Portsmouth Harbor, the long series of trials occupying only about ten days, including a Sunday and a day of fog.

LEVIATHAN.

The armored cruiser *Leviathan*, built, armored, and engined by Messrs. John Brown & Co., has had her steam trials which have been successful. On May 13 and 14, 1902, she ran her thirty-hours' trial at one-fifth her power, when she drew 26 feet 1 inch forward and 26

feet 6 inches aft, and she had a steam pressure of 200 pounds to the square inch in her boilers. The vacuum was 26 inches starboard and 25 inches port, and the revolutions 70.6 starboard and 70.9 port. The collective I. H. P. was 6,372, being 3,182 starboard and 3,190 port; the speed was 15.238, which was the mean of four runs over the measured mile, and the coal consumption was 1.76 pounds per unit of power per hour. She left Spithead on May 15 for her two more important trials, which were mainly carried out on the Cornish measured distance. At her four-fifths power trial she drew 26 feet $2\frac{1}{2}$ inches forward and 26 feet 3 inches aft, and had 245 pounds of steam in her boilers, with an even vacuum of 26 inches on both sides. The revolutions were 107.3 starboard and 107 port, and the collective I. H. P. 22,882, being 11,584 starboard and 11,298 port. There was no air pressure, and the speed was 21.96 knots with a coal consumption of 1.75 pounds per unit of power per hour. On May 19 she left Plymouth for her eight hours' full-power trial, when she drew 26 feet 2 inches forward and 26 feet $2\frac{1}{2}$ inches aft, and had 280 pounds of steam in her boilers, the vacuum being 25.6 inches starboard and 25.5 inches port. The revolutions were 121.2 and 120.8, respectively, obtained by 31,203 I. H. P.—15,829 starboard and 15,374 port. The mean air pressure was 0.35 inches, and the speed 23.23 knots with a coal consumption of 1.94 pounds per unit of power per hour.

DRAKE.

At her eight hours' full-power trial in June, 1902, the first-class armored cruiser *Drake* made four runs over the deep-sea course off Portsmouth with the following results: Draft, forward and aft, $26\frac{1}{2}$ feet; steam pressure in boilers, 292 pounds; vacuum, starboard, 26.25 inches, port, 26.5 inches; revolutions, 116 starboard and port; total collective I. H. P., 30,849; mean speed, 23.05 knots; coal consumption per I. H. P. per hour, 1.83 pounds. The *Drake* and the *Good Hope* made the same speed at their full-power trials.

SPARTIATE.

The first-class protected cruiser *Spartiate*, which has made several ineffectual efforts to go through her speed trials, was examined by the Portsmouth Dockyard officials, and the whole of her condenser tubes, numbering 10,500, condemned. As they will all have to be removed, and new tubes substituted, several months will elapse before the ship can resume her trials. At the last run so many tubes broke right across when the ship was running at full power that it was considered dangerous to continue the trial.

ESPIEGLE.

The *Espiegle*, sloop, built at Sheerness Dockyard, completed her official steam trials in August, 1901, the results being as follows: Thirty

hours' trial at three-fourteenths full power: Pressure of steam in boilers, 204.9 pounds; pressure of steam at engines, 202.2 pounds; vacuum, starboard, 26.48 inches; port, 26.04 inches; revolutions, starboard, 124.8; port, 126.3; I. H. P., starboard, 175.7; port, 162; total I. H. P., 337.7; speed, 10 knots; coal consumption, 1.53 pounds per I. H. P. per hour. Trial at five-sevenths full power: Pressure of steam in boilers, 211.6 pounds; pressure of steam at engines, 197.4 pounds; vacuum, starboard, 26.4 inches; port, 26.4 inches; revolutions, starboard, 178.7; port, 179.3; I. H. P., starboard, 515.7; port, 515.2; total I. H. P., 1,030.9; speed, 13.5 knots; coal consumption, 1.55 pounds per I. H. P. per hour. Eight hours' full-power trial: Pressure of steam in boilers, 213.1 pounds; pressure of steam at engines, 198.9 pounds; vacuum, starboard, 26.72 inches; port, 26.84 inches; revolutions, starboard, 197.6; port, 200.6; I. H. P., starboard, 720.2; port, 704.8; total I. H. P., 1,425; speed, 13.5 knots; coal consumption, 1.69 pounds per I. H. P. per hour.

Her commissioned steam trial was successful. The following are the details: Pressure of steam in boilers, 223.3 pounds; pressure of steam at engines, 215 pounds; vacuum, starboard, 27.2 inches; port, 26 inches; revolutions, starboard, 198.6; port, 199.2; I. H. P., starboard, high 208, intermediate 270, low 238; port, high 204, intermediate 253, low 233; total I. H. P., 1,406; speed, 12.3 knots. The *Espiegle* will complete preparations for her departure for China.

FANTOME.

The sloop *Fantome* successfully completed her thirty hours' steam trial at three-fourteenths her full horsepower. With a mean pressure of 180 pounds of steam in her boilers and her engines working 126 revolutions per minute, a mean of 339 horsepower was indicated, with a speed of $9\frac{1}{4}$ knots per hour. The coal consumption averaged 1.71 pounds per I. H. P. per hour. At the conclusion of the trial the machinery of the *Fantome* was worked for an hour at 1,000 horsepower with satisfactory results. The *Fantome* left Sheerness on January 10 for a thirty hours' run at 1,000 horsepower.

The particulars of the thirty hours' steam trial at five-sevenths her full horsepower are as follows: Pressure of steam in boilers, 216 pounds; pressure of steam at engines, 209 pounds; vacuum—starboard 27.7 inches, port 27.2; revolutions—starboard 178.9, port 175.6; I. H. P.—starboard, high 158, intermediate 170, low 183; port, high 165, intermediate 167, low 177; total I. H. P., 1,020; speed, 12.5 knots; coal consumption, 1.54 pounds per I. H. P. per hour.

Particulars of her eight hours' full-power trial, which proved successful, are as follows: Pressure of steam in boilers, 218 pounds; pressure of steam at engines, 203 pounds; vacuum—starboard 27.6 inches, port 26.6 inches; revolutions—starboard 200.9, port 198.8; I. H. P.—

starboard, high 219, intermediate 244, low 267; port, high 230, intermediate 238, low 255; total I. H. P., 1,453; speed, 13.63 knots; coal consumption, 1.54 pounds per I. H. P. per hour.

RINALDO.

The sloop *Rinaldo* had her commissioned steam trial on December 19, 1901, at which her machinery and Belleville boilers worked very satisfactorily. With a mean pressure of 234 pounds of steam in the boilers, and engines working at 199.2 revolutions per minute, an average of 1,424 I. H. P. and a speed of 13.4 knots per hour were obtained.

TEAL.

The shallow-draft gunboat *Teal* was launched with steam up May 18, 1901, and five days later had her official trials. After six runs over the measured mile a three hours' trial was proceeded with, during which a mean speed of 13 knots was maintained with 282.6 revolutions. During one hour of this trial wood fuel only was used.

MOORHEN.

The shallow-draft gunboat *Moorhen*, built by Yarrow, had a three hours' trial on August 21, 1901, and easily attained the speed of 13 knots without forcing the draft.

RACEHORSE.

The torpedo-boat destroyer *Racehorse*, which was built and engined by Messrs. Hawthorne, Leslie & Co., of Newcastle-on-Tyne, completed her steam trials on December 17, 1901, and returned to Chatham to be prepared for service. The three hours' full-speed trial proved very successful, a speed of 30.354 knots being obtained during six runs on the measured mile, while the average for the three hours was 30.345 knots.

EXPRESS.

The steam trials of the destroyer *Express*, after having been several times postponed on account of bad weather, were concluded on the Clyde during the week ending November 16, 1901. The results were very satisfactory, a mean speed of 30.16 being recorded for a four hours' run at full power.

GREYHOUND.

The torpedo-boat destroyer *Greyhound*, built by Messrs. Hawthorne, Leslie & Co., underwent a successful three hours' official coal-consumption trial at full power on September 7, 1901. During six runs on the measured mile an average speed of 30.424 knots was obtained, while the average for the full time was 30.157 knots. The machinery

worked smoothly. The steam pressure in the boilers was 244 pounds per square inch, while the revolutions were 398 per minute. The I. H. P. was 6,141, and a speed of 30.337 knots was obtained.

ROEBUCK.

The torpedo-boat destroyer *Roebuck*, built and engined by Messrs. Hawthorne, Leslie & Co., of Newcastle-on-Tyne, left Chatham on September 27, 1901, for her three hours' official coal-consumption trial. Excellent results were obtained. During six runs on the measured mile a speed of 30.436 knots was obtained, one mile with the tide being covered in 1 minute and 49 seconds. The average speed for the three hours was 30.346 knots. The steam pressure in the boilers was 246 pounds per square inch, the vacuum in the condensers being 22.6 starboard and 22.2 port. The I. H. P. was 4,295 starboard and 3,242 port; total, 6,357.

SUCCESS.

The torpedo-boat destroyer *Success*, built and engined by Messrs. Doxford & Sons, Sunderland, carried out on February 28, at Portsmouth, her three-hours' 30-knot full-power trial. She had 254 pounds of steam in her boilers and a mean air pressure of 5.7 inches. The I. H. P. was 6,597, and the mean of six runs over the measured mile showed a speed of 29.908 knots, while the mean speed of the three hours was 30.023 knots.

SYREN.

The *Syren*, the last of a series of thirteen 30-knot destroyers supplied by Palmer's Shipbuilding Company, carried out her full-power trial at Portsmouth on September 10, 1901. The first boat of the series was the *Star*, which had a serious accident on her first trial, but since then the whole of the boats have been run with such remarkable success that the only cause of abandonment of trial has been bad weather. At the full-power trial on Tuesday the *Syren* drew 5 feet $1\frac{3}{8}$ inches forward and 9 feet $\frac{3}{4}$ inch aft. She had 245 pounds of steam in her boilers, and the vacuum was 25 inches starboard and port. The revolutions were 382.9 starboard and 380.2 port, and the total I. H. P. was 6,708. The air pressure was 3.6 inches, and the mean speed of the three hours was exactly 30 knots. During the early part of the trial the vessel made six runs over the measured mile in Stokes Bay, when the mean I. H. P. was 6,689 and the speed 29.812.

These results correspond with those obtained at the coal-consumption trial on September 5, when the mean speed of the three hours was 29.764 knots and the I. H. P. 6,665. Between the two trials the coal was weighed and the consumption was found to be 2.4 pounds per I. H. P. per hour. The speed and economical results do not appear to compare favorably with the *Syren's* predecessors, built by the same

firm, but it should be explained that the vessel carried 40 tons more load than the *Star*, the first of the series, and 30 tons more than the *Myrmidon*, the eleventh of the list.

An interesting feature of both trials of the *Syren* was the use of the automatic lubricator, the invention of Mr. Reed, who is the patentee of the boiler used in all the destroyers built by the Palmer's Ship-building Company. The oil, after being pumped in at the end of the shaft, is forced through all the rods and bearings, and after returning to the reservoir is sent on its course again. The saving of the manual labor is comparatively unimportant, but the certainty that every part of the machinery is regularly and systematically lubricated has been clearly demonstrated, and hence a great saving of wear and tear may be expected.

NO. 107.

Torpedo boat No. 107 passed her final official full speed trial at the mouth of the Thames on September 23, 1901. The mean speed on the measured mile was 25.401, and that for three hours 25.206, the I. H. P. being 2,899. The notable features of the trial were the smoothness with which the engines worked, the low air pressure in the fire-rooms (1.6 inches), and the handiness of the boat in turning. The diameter of the circles at full speed was not more than three lengths under starboard helm and four lengths under the port helm, the boat remaining practically upright. The trial was made with the full seagoing load of 42 tons on board, which is much in excess of the 35 tons carried on the trials of 30-knot torpedo-boat destroyers of twice the displacement. The strength and stiffness of the hull were clearly shown by the remarkable absence of vibration. This is the third of four similar vessels building for the Admiralty by Messrs. John I. Thornycroft & Co., Limited, of Chiswick.

NO. 108.

The new torpedo boat No. 108 went into the Channel on October 18, 1901, to carry out her three hours' full-power trial. After an hour's run the trial was abandoned, the vessel having failed to obtain the required speed.

Later she successfully passed her official full-power coal trial of three hours' duration. The engines developed a mean of 2,876 I. H. P., which gave a speed of 25.359 knots with 385.5 revolutions of the engines. The air pressure was 2 inches to 2.5 inches. The coal consumption was 2.009 pounds per I. H. P. per hour. This is said to be one of the best results obtained with either destroyers or torpedo boats. The boilers are of the latest Thornycroft-Schulz type, in which the gases enter the tubes attached to the lower central barrel, and then

proceed over the firebox down toward the wing barrels, thence up the funnel.

On November 18 she had a three hours' full speed trial in the North Sea. Good results were attained, and the trial proved a success. The speed on the measured mile was 25.446 knots, while the mean speed for the three hours was 25.332. The official details are. Draft of water, forward 5 feet $3\frac{3}{4}$ inches, aft 8 feet $5\frac{1}{2}$ inches; steam pressure in boilers, 220 pounds per square inch; vacuum in condensers, 24.7; revolutions per minute, 385.5; mean pressure in receivers, high 247, intermediate 84, low 30; mean pressure in cylinders, high 84.8, intermediate 30.4, forward low 20.9, after low 30.9; mean I. H. P., high 1,028, intermediate 723, forward low 516, after low 516, total, 2,783.

SUBMARINE BOAT NO. 1.

Submarine boat No. 1 was put through an important series of trials in Barrow docks during April, 1902. She first underwent surface tests with the view of ascertaining the results attending the erection of a brass conning tower, which was originally composed of steel, as well as a new steering wheel, now fixed to the boat close to the tower, which can be worked from above and below alike. These improvements, it is understood, proved highly satisfactory. This was the first time the craft had been entirely under water. She proceeded at a slow pace along the dock, and was seen to sink at the bow and then suddenly disappear from sight, a few inches of the periscope only being visible. The sinking was executed in the space of a few seconds. There were five persons on board and the vessel was submerged for over two hours, the crew feeling not the slightest inconvenience. This preliminary test gave the greatest satisfaction, the boat behaving admirably at a depth of about 9 feet.

A noteworthy feature of the tests was her excellent diving propensities, which for three days were put to the severest trials. In this respect it is intended the boat, on sighting its object for "destruction," shall immediately dive down, first of all as far as the small conning tower, in which position she can travel if necessary for a distance of 400 miles. When within suitable range—say about 2,800 yards—she goes completely below the surface, a lookout being kept by means of the periscope, which reflects down into the boat any objects ahead, when she is under to the depth of about 10 feet.

It was expected that this operation could be accomplished in a very short time, and the exhaustive tests of No. 1 boat have shown the surmise to be quite correct. In fact, the boat, after submerging to the tower, suddenly disappeared, and then came again in sight some yards distant with remarkable rapidity, the diving being continued at intervals, for several hours at a time, without any perceptible hitch.

Seven persons were on board the submarine, and the vessel repeat-

edly ran the length of the dock submerged a few feet below the surface of the water. The trials were accomplished in a remarkably short time, the submerging not taking more than six seconds, while the ascent to the surface was made in a very little longer time. The operations were continued for some time, the vessel being kept on a straight course. The steam launch *Cayzer*, with admiralty and other officials on board, was in attendance.

These tests having proved successful, the boat was taken out into the Irish Sea, escorted by the tug *Furness*, on board of which were divers ready for instant action in case of accident. All went well with the submarine, and it is reported that her open-sea trials, which took place off the west coast of Walney Island, were successful. The vessel was submerged to a depth of 15 feet and ran 6 miles under these conditions. She remained off Walney until late in the evening waiting for the flood tide, upon which, attended by the tug, she returned safely to Barrow.

FRANCE.

SUFFREN.

This first-class battleship began her trials in March, 1902, but the boilers having failed to reach the contract requirements in the evaporative tests, the trials were postponed.

The boilers on the *Suffren* are of the Niclausse type. The evaporative efficiency called for by the contract was 1 pound of steam per pound of coal at the rate of combustion of 20 pounds per square foot of grate, or $8\frac{1}{2}$ pounds of steam per pound of coal at the rate of combustion of $26\frac{1}{2}$ pounds per square foot of grate. During the first evaporation trials this efficiency was not attained, although the boilers worked well, and the tubes inspected after each trial were found to be absolutely straight, no part of the tubular compartment showing the least trace of fatigue.

It was believed that the failure of the boilers was due to defective air supply under natural conditions, and one boiler was therefore slightly modified by changing the distances between the grate bars of the furnace and by the introduction of a form of baffle-plate in the tubular compartment. This has proven very satisfactory with the boiler in position in the *Suffren*. All the boilers will receive the same treatment, and the trials will then be resumed.

IÉNA.

This new battleship, an account of whose preliminary trials is given on page 124, General Information Series No. XX, completed her trials off Brest July 16, 1901. At the two hours' full-speed trial the engines developed 16,500 I. H. P., making 125 revolutions and giving a speed of 18.2 knots, with a coal consumption of 1.72 pounds per horsepower per hour.

MONTCALM.

This armored cruiser had her coal-consumption trials in November, 1901, with the following results: I. H. P., 19,799; speed, 21 knots; coal per horsepower per hour, 1.79 pounds.

On December 31, 1901, she finished a twenty-four hours' trial, when the engines developed 11,300 horsepower, giving a speed of 19 knots and a coal consumption per horsepower per hour of 1.48 pounds.

JEANNE D'ARC.

This armored cruiser began her acceptance trials off Toulon in July, 1901, but the results have not been satisfactory.

The ship is intended to go 23 knots with 1,400 tons of coal, her normal supply, in her bunkers; but up to the present, although carrying less coal, a speed of 18 knots only has been reached, as the bearings have become hot when the engines have been run up to 110 revolutions, although at full speed they are supposed to make 120 revolutions; moreover, serious defects have developed in the feeding of the boilers, which are of the small-tube Guyot type, and the temperature of the fire rooms is so high that they are quite unbearable. On a recent trial, with 24 boilers alight out of 30, fires had to be hauled in no less than 20, and with only 4 boilers working the ship had to crawl back to Toulon at 3 knots. It is stated that her boilers may have to be removed and others of a different type substituted.

CHATEAURENAULT.

This first-class protected cruiser, an account of whose preliminary trials is given on page 125 of General Information Series No. XX, has finished her full-speed trials sufficiently well to be accepted by the Government, but they can not be called successful.

About July 27, 1901, she had a full-power trial, lasting one hour and a half, when the engines developed 23,200 I. H. P., making 129 revolutions and giving a mean speed of 23.75 knots.

About August 31, 1901, she had full-power trials over the course off the Hyeres Islands. The trial consisted of three runs over the measured course, with the following results: First run, speed 24.043 knots; second run, speed 24.344 knots; third run, speed 24.067 knots. From these the mean speed arrived at was 24.148 knots. The engines developed 23,680 I. H. P.

After the trials had been finished the commission decided to propose the changing of the heads of the connecting rods and of a certain number of the bearings to diminish the heating which occurred when running at full speed.

About January 17, 1902, a further effort was made to hold full-speed trial, but trouble occurred with the central engine, and the trial was postponed.



MONTCALM, FRENCH ARMORED CRUISER, 9,516 TONS.

In February she had a six hours' trial, with the following results: I. H. P., 18,500; revolutions, 120.2; average speed, 21.8 knots; coal consumption per horsepower per hour, 1.42 pounds.

In the twenty-four hours' endurance test, which took place February 14, 1902, she was able to fulfill her contract, and even made greater than contract speed for the necessary three hours, but she was not pushed to her top speed. They did not dare to force the central engines, which have never been satisfactory. In continuing the trials at reduced speed some of the tubes gave out and a propeller blade was carried away. Perhaps the worst of all is the fact that at about 20 or 21 knots the vessel is scarcely habitable in consequence of the excessive vibration. In the earlier trials the vibrations were extraordinary, and it was sought to remedy them by shoring up, extra stanchions being carried from the skin up through all decks. Her later trials showed, however, that the shoring-up process only made the vibrating motion a series of hard shocks, actually unendurable except for a comparatively few hours. Certainly one, perhaps all, of the propellers are to be changed, in the hope of reducing the motion. When she will be ready for actual service is uncertain.

JURIEN DE LA GRAVIERE.

This second-class protected cruiser commenced her trials at Lorient during the latter part of May, 1902, and attained a speed of 21.5 knots. Owing to a defect that developed in one of the cylinders of her central engine the trials had to be postponed.

REQUIN.

This reconstructed armored coast-defense vessel had her full-speed trial at Cherbourg January 15, 1902, making 15.3 knots, with 6,350 I. H. P. This was followed by a twenty-four hours' trial, during which she attained a speed of 13.97 knots, with 83 revolutions and 4,721 I. H. P. The coal consumption per horsepower per hour was 1.537.

The *Requin* is fitted with boilers of the improved Niclausse type. She has been sent to Toulon and placed in the reserve "second category."

SIROCO AND MISTRAL.

Normand & Co., of Havre, have recently delivered to the French Government, at Cherbourg, two protected torpedo boats, fitted with the same machinery and boilers as the *Cyclone*. The trials, held in August, 1901, offer special interest on account of the very heavy weights carried. The dimensions are: Length on load line, 147 feet; extreme breadth outside armor, 16 feet 10 inches.

The nickel-steel armor extends to the machinery and boiler compartments and is distributed as follows: 1-inch—vertical sides from 1 inch

below the water line to the deck; fore-and-aft bulkheads from 16 inches below the water line to the deck; vertical sides of coverings of all parts of machinery and boilers and of the steering engine above deck. Eleven thirty-seconds of an inch—all horizontal parts of deck and hatchways.

The total extra weight resulting from the addition of armor, including the strengthening of the hull amidships and the addition of a central hollow keel 1 foot high, extending to about one-half the length of the boats, and intended to stiffen the central part of the structure and to check rolling, is not less than 24 tons.

The hulls are very strong, as was proved by an accident which occurred to an exactly similar protected torpedo boat in a trial outside Lorient. When steaming at about 23 knots, during foggy weather, she ran end on against a rock rising above water; and, although several men were injured by the shock, no material damage, beyond the crushing of about 25 feet of the fore part, occurred to the boat, which was towed back to harbor.

The total other weights carried on trial, exclusive of chains, anchors, masts, boats, etc., and comprising only torpedo tubes and compressing pump, artillery and ammunition, fresh water for boilers and crew, coal necessary for steaming 1,920 nautical miles at 14 knots, crew and effects, provisions, including 5 tons for sundries to complete displacement at sea, amounted to 39.9 tons in the *Siroco* and 43.2 tons in the *Mistral*. Accordingly, the displacement on trial, 177.5 tons for the *Siroco* and 178.7 tons for the *Mistral*, was that of the boats on service.

It has been the general custom of the French Admiralty to have the trials of ships made at what was believed to be full load; but lately this rule has been enhanced, as it was ascertained that these full-load trial displacements were often inferior to the real displacements on service.

If the 24 tons due to armor are added to the above weights, the total weights carried on trial amount to 63.9 and 67.2 tons, respectively, or about 37 per cent of the total displacement. This is far from the 35 tons carried on board destroyers of much larger displacement. The weight of coal put on board was determined by an eight hours' preliminary trial.

The full-speed trials, which took place after the ordinary preliminary runs on the measured mile, were of four hours' duration, one hour of which was to be run at 22 knots, one hour at a maximum speed, and the next two hours at 22 knots.

The one-hour maximum speed was found to be 28.341 knots for the *Siroco*, the engines making 355 revolutions, and 28.102 knots for the *Mistral*, with 351 revolutions. Only 26 knots were due according to contract. The maximum speed of the *Cyclone* (unprotected), with a displacement of 141 tons, was 30.7 knots.

After the full-speed trials, further trials were made under a single boiler, when the *Siroco* maintained a speed of 20.7 knots, with 267 revolutions.

SIMOUN, TYPHON, AND TROMBÉ.

These high-sea torpedo boats, of the same type as the *Siroco*, have had their trials.

On August 31, 1901, on her full-speed trials off Havre, the *Simoun* made 27.7 knots.

On November 9, 1901, the *Typhon* arrived at Cherbourg from Havre, having maintained an average speed of 29 knots. In her subsequent trials off Cherbourg, in January and February, she attained a speed of 27.8 knots with 349.7 revolutions, and 28.21 knots with 354 revolutions.

The *Trombé* completed her trials at Lorient, and attained a speed of 26.6 knots.

BOURRASQUE, BORÉE, RAFALE, AND TRAMONTANE.

These high-sea torpedo boats are similar to the *Siroco* type, but their displacement is 20 tons less.

The *Bourrasque*, in November, 1901, made the trip between Cherbourg and Havre at the average speed of 29 knots under ordinary working conditions. In December she had an eight hours' trial with the following results: Revolutions, 185.55; average speed, 14.365 knots; coal consumption, 496 pounds per hour. In March, 1902, on her four hours' full-speed trial, she made 31.41 knots with 347.12 revolutions.

The *Borée* on September 7, 1901, at Rochefort, made 25.5 knots on her trials. On November 18 she made 29.5 knots.

The *Rafale* carried out a four hours' speed trial at Cherbourg, in February, 1902, with the following results: Revolutions, 347; speed, 31.47 knots.

The *Tramontane*, on July 25, 1901, attained a speed of 23 knots with 290 revolutions during a three hours' trial, and 29.8 knots with 339.5 revolutions during an hour's run at full speed.

NOS. 253, 254, 255, AND 256.

These first-class torpedo boats have had satisfactory trials. In October, 1901, No. 253 completed its consumption and working trials with an average speed of 14.18 knots. The coal consumption was 391.3 pounds per hour, while at 14 knots this was reduced to 376.6 pounds. In November a speed of 25.36 knots was obtained with 340 revolutions.

On October 21, 1901, the coal-consumption trials of No. 254 resulted as follows: Average speed, 14.26 knots; revolutions, 194.68; coal per

hour, 391.32 pounds. On November 24, 1901, a speed of 25 knots was obtained with 342.86 revolutions.

On January 22, 1902, No. 255 attained a speed of 25.608 knots with 345.25 revolutions.

In February No. 256 had an eight hours' coal-consumption trial with the following results: Speed, 14 knots; revolutions, 192.3; coal consumption per hour, 391.3 pounds; coal consumption per mile, at 14 knots, 25.43 pounds.

SUBMARINES.

The *Espadon* underwent its first submersion trial October 3, 1901, at Cherbourg. She was under water for four hours. Everything went well, and the crew experienced no discomfort.

The same vessel carried out surface trials October 21, making use of her steam machinery. The average speed obtained was 8.7 knots with 380 revolutions; at highest power, with 420 revolutions, the speed should be more than 10 knots.

The *Espadon* was then submerged for two and a half hours, taking less than eight minutes to reach a depth of about 30 feet.

The first trials of the *Silure* commenced at Cherbourg December 20, 1901. The time occupied in disappearing was ten minutes, but this will, it is hoped, be reduced to six minutes.

In April the *Silure* made some interesting experiments outside the harbor of Cherbourg. Among other things, it sank to a depth of 134.5 feet, at which depth it was found that the hull was compressed to the extent of one-twenty-fifth of an inch. No inconvenience was felt by the crew greater than that experienced at a depth of from 20 to 25 feet.

On June 14, 1902, the *Silure* left Cherbourg at 9 a. m. to make a twenty-four hours' trial trip in the open sea. She finished her maneuvers on the surface at 2 p. m., and then went under water, where she remained at a depth of nearly 4 fathoms for two hours, when suddenly three quartermasters became unconscious. For a moment the crew became panic stricken, but the lieutenant in command immediately gave orders for the boat to be brought to the surface, and made at once for Cherbourg, arriving there at 5 p. m. The unconscious men were at once transferred to the naval hospital, where it was found that they were suffering from carbonic acid gas poisoning.

The *Triton* underwent her surface trials October 3, 1901, at Cherbourg. She traveled 40 miles at an average speed of 10 knots.

The newspapers of France give much attention to the performances of their submarine and submersible boats, "submarine" being the term applied to boats of the *Morse* type and "submersible" to those of the general type of the *Narval*. Nearly every day short paragraphs

appear relating to the experiments made with one or another of these boats. While the published accounts always, or nearly always, give unstinted praise and pronounce the experiments a success, the fact remains that details are rarely given, and the success obtained is probably not so great as usually described in the press. One of the experiments for endurance was made by the *Triton* (submersible), which left Cherbourg on December 7, 1901, with all her materials, stores, and four torpedoes, and, after clearing the breakwater, experimented in diving and traveled during two hours under water. Then, coming to the surface, fires were lighted and she continued her journey to the eastward, passing Cape de la Heve, near Havre, during which time she recharged her accumulators and compressed-air tanks. Without landing, she turned and returned to Cherbourg, experiencing bad weather. The crew remained under closed hatches for nearly the entire trip. It is stated that, while the temperature below reached 122° F., the men bore the journey very well. She reached Cherbourg at 10 o'clock next morning, after a continuous run of twenty-four hours, and everything is said to have worked well.

GERMANY.

KAISER BARBAROSSA.

This battleship had her trials from June 17 to July 6, 1901. The following table shows the results:

	First trial.	Second trial.
Duration of trials hours..	50	6
Draft before:		
Forward feet..	24.27	24.41
Aft do....	27.03	26.83
Draft after:		
Forward..... do....	22.90	23.85
Aft do....	26.70	26.83
Indicated horsepower main engines.....	7,360	13,940
Revolutions.....	94	112.8
Coal consumption per horsepower per hour..... pounds..	1.83	
Coal consumption per square foot of grate surface per hour (cylindrical boilers)..... pounds..	17	
Coal consumption per square foot of grate surface per hour (tubulous boilers)..... pounds..	15	
Speed knots..	15.5	18
Air pressure in—		
Cylindrical boilers inches..		0.4
Tubulous boilers do....		2

KAISER KARL DER GROSSE.

As the result of the ship running aground when being conveyed from Hamburg to Wilhelmshaven and the repairs necessitated thereby, the trials of this battleship were delayed until January, 1902. After

successful preliminary trials, which took place from January 9 to the latter part of February, the six-hour trial trip under forced draft was made on March 6.

The results of the trials were: Mean I. H. P., 13,833; revolutions, 116; air pressure, water-tube boilers, 1.5 inches water column, cylindrical boilers, 0.45-inch water column. The speed was about 18 knots, but, owing to the dark weather, it could not be ascertained exactly.

THETIS.

The *Thetis* had her forced draft, six-hour trial October 19, 1901, which proved satisfactory. Following are the particulars: Draft before trial, forward 14.79 feet, aft 17.06 feet; draft after trial, forward 14.1 feet, aft 17.06 feet. The I. H. P. developed was 8,888, with 172 revolutions, and a speed of 21.75 knots per hour. The air pressure under grate was 2.4 inches water column. The coal consumption was not measured.

S-107.

This torpedo-boat destroyer made her trial trips all in one week, comprising the engine maneuvering trip, rudder maneuvering trip, forced trial trip, and trips under forced draft over the measured mile. The speed attained was 28.3 knots.

G-108.

This torpedo-boat destroyer, built at the Germania Works, at Kiel, made trial trips over the measured mile March 22, 1902. Under the contract requirements the vessel was to have a speed of 26 knots, but she reached a maximum of 28.8 knots in shallow water, and the opinion of the experts is that in deep water she will be able to make 30 knots. The trials were made with full war equipment.

Later reports state that a speed of 30 knots has been attained by this destroyer, but that during one of the trials the stern-post broke.

HOLLAND.

RINDJANI.

The last of the three torpedo boats built by Yarrow, at Poplar, the *Rindjani*, of 138 tons, was launched July 2, 1901, and immediately after began a series of progressive speed trials. The vessel was drawing 3 feet 9 inches forward and 4 feet 7½ inches aft, giving a mean of 4 feet 2¼ inches, the total load being 49.5 tons. Ten runs were made on the measured mile, two runs in each direction giving 19.999 knots, two at 20.898 knots, two at 22.817 knots, two at 23.392 knots, and two at 24.161 knots, the slip of the propeller decreasing from 15.5 to 11.9 per cent. Then six runs were made at full speed, the mean result being, boiler pressure, 200 pounds; at engines, 186.6 pounds; at steam

chest, 180 pounds; first receiver, $71\frac{3}{4}$ pounds; second receiver, $12\frac{1}{2}$ pounds; vacuum, 23 inches; air pressure in fire room, 1.9 inches; revolutions, 368.7; speed, 25.59 knots, and average slip, 12.1 per cent. The vessel continued running for some time at this speed, and the coal burned throughout the trial, which lasted seven hours, was 7 tons 10 hundredweight, the draft upon the return being, forward, 3 feet 6 inches; aft, 4 feet 7 inches; mean, 4 feet $\frac{1}{2}$ inch.

ITALY.

NEMBO.

The torpedo-boat destroyer *Nembo*, of 350 tons, built by Pattison, of Naples, finished her trials October 28, 1901. With steam pressure of 170 pounds per square inch in her boilers she made 18.3 knots with 1,158 horsepower, and 19.3 knots with 1,444 horsepower. With 200 pounds' steam pressure, 24.7 knots with 2,994 horsepower, 25.6 knots with 3,350 horsepower, 26.6 knots with 3,850 horsepower, and 27.2 knots with 4,907 horsepower. Finally, with 200 pounds steam pressure, 20.8 knots with 1,966 horsepower, and 22.3 knots with 2,123 horsepower. On a four hours' trial, with a steam pressure of 220 pounds, and a mean horsepower of 5,350, a speed of 30 knots was obtained, the maximum being 5,724 horsepower, with a speed of 30.56 knots. On a three hours' forced draft trial, with a steam-pressure of 200 pounds and 5,278 horsepower, a speed of 30.2 knots was obtained; revolutions, 369.

The coal-consumption trial of six hours, with natural draft, gave 3,314 horsepower, 25.1 knots speed, and 311 revolutions, with 1.94 pounds of coal per horsepower per hour. At this speed, with a maximum of 80 tons on board, the radius of action would be about 680 miles.

DELFINO.

A number of successful trials have been carried out with the submarine boat *Delfino*. The *Delfino* was built at Spezia in 1896, and several successful series of experiments were carried out with her, but in one of her dips she fouled the *Maria Pia's* bottom and could not be cleared until the battleship weighed and shifted berth. After this her trials were given up, but they were recommenced in August, 1901. She is constructed of steel, in the form of a cigar; is about 72 feet long, with a diameter of 8 feet 6 inches; when completely immersed she has a displacement of about 107 tons. The motive power is furnished by a battery of 300 accumulators, which give her a speed of 8 or 9 knots on the surface of the water. She is driven by a screw, there being 2 small screws in addition for submerging her or sending her to the surface. She carries 2 torpedo tubes forward. The provision of air is sufficient for 12 men for seven or eight hours. The

Delfino is to be fitted with a new periscope, the invention of two engineers in the Royal navy—Senori Russo and Laurenti. The new instrument is called the cleptoscope, and it is claimed for it that while the tube which is visible above the water is only 5 inches in diameter, it has a field of view of 60 degrees, which is without distortion and extends to the horizon. The original French periscope has only a field of 3 or 4 degrees, and with it it is extremely difficult to locate objects, while in the latest pattern the tube is over 13 inches in diameter, while the objects in the field are said to appear blurred and distorted.

TURBINE.

The torpedo-boat destroyer *Turbine*, of 350 tons, built at the Pattison Works, Naples, has had her trials under forced draft, with a displacement of 270 tons. With a steam pressure of 204 pounds, 5,306 I. H. P. was developed; revolutions, 369; speed, 30.16 knots. On her coal-consumption trial under natural draft 3,257 I. H. P. was developed, giving 25.2 knots, with 313 revolutions, and a coal consumption of 1.9 pounds per horsepower per hour.

JAPAN.

MIKASA.

This new battleship completed a series of official trials in the English Channel in January, 1902. On a deep sea measured course off the coast of Devon the vessel attained a speed of 18.6 knots, developing a mean I. H. P. of 16,400, which is in excess of the guaranteed results, namely, 18 knots and 15,000 I. H. P.

On a coal-consumption trial of six hours' duration, at four-fifths of her full power, it was found that with 12,235 horsepower the coal consumption worked out to 1.53 pounds per horsepower per hour, while the guarantee was 2 pounds. The boilers, which are of the Belleville type, were worked entirely by the Japanese crew. On the six hours' trial the speed was 17.3 knots. The engines worked most satisfactorily on all the trials.

CHIHAYA.

This dispatch boat of 1,250 tons displacement, built at Yokosuka, collided with a torpedo boat destroyer on her trial trip, but sustained only slight damage. Her estimated speed was 21 knots, but she made 22 knots on her forced-draft trial.

AKATSUKI.

The following table shows the results of the three hours' official trial of this destroyer, held November 21, 1901. A load of 40 tons was carried:

Run.	Hour.	Boiler steam.	First intermediate receiver.	Second intermediate receiver.	Vacuum.	Air pressure in fire room.	Revolutions per minute.	Time.	Speed.	First mean.	Second mean.	Admiralty mean.
	<i>a. m.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Ins.</i>	<i>Ins.</i>		<i>m. s.</i>				
1.....	11.8	229	64	12.5	22.3	1.5	407.0	1 51	32.432	} 30.779 } 31.354 } 31.545 } 31.192 } 31.438	} 31.067 } 31.450 } 31.368 } 31.315	} 31.300 knots per hour on measured mile.
2.....	11.18	229	63	12.5	22.3	1.6	401.4	2 3.6	29.126			
3.....	11.28	233	66	14.0	22.0	1.7	414.2	1 47.2	33.582			
4.....	11.38	236	66	13.9	21.5	1.3	403.5	2 2	29.508			
5.....	11.47	232	65	13.4	21.3	1.3	408.5	1 49.5	32.876			
6.....	11.57	240	65	13.7	20.8	1.1	403.5	2 0	30.000			
Mean on miles.....		233	65	13.3	21.7	1.4	406.35					

NOTE.—Means for the three hours' trial: Two hundred and thirty pounds steam; 64 pounds in first intermediate receiver; 13 pounds in second intermediate receiver; 20.3-inch vacuum; air pressure in fire rooms, 1.3 inches; mean revolutions per minute, 404; mean speed during three hours, 31.121 knots; I. H. P., 6,450; coal consumption on the three hours' continuous run, 1.97 pounds per horsepower.

KASUMI.

The following table shows the result of the three hours' official trial of this destroyer held on January 29, 1902. A load of 40 tons was carried:

Run.	Hour.	Air pressure in fire room.	Revolutions per minute.	Time.	Speed.	First mean.	Second mean.	Admiralty mean.
	<i>a. m.</i>	<i>Inches.</i>		<i>m. s.</i>				
1.....	11.13	0.6	395.8	2 40	29.032	} 30.969 } 30.795 } 31.087 } 31.236 } 31.394	} 30.882 } 30.941 } 31.161 } 31.315	} 31.075 knots on measured mile.
2.....	11.24	.93	382.1	1 49.4	32.906			
3.....	11.33	.9	390.3	2 5.5	28.685			
4.....	11.43	1.1	396.8	1 47.5	33.488			
5.....	11.54	1.1	398.1	2 4.2	28.985			
6.....	12.3	1.2	401.7	1 46.5	33.802			

After the six runs were made, to ascertain the advance per revolution of the screw, a three hours' trial was proceeded with, with the result that a mean speed during the three hours of 31.245 knots was obtained.

SHIRAKUMO.

This torpedo-boat destroyer underwent a successful full-speed trial on January 5, 1902, in very boisterous weather at the mouth of the Thames. In spite of the unfavorable conditions, the mean speed maintained during the three hours' trial was 31.030 knots.

The results of six runs over the measured mile were as follows.

the conditions of load, etc., being very similar to those for British Admiralty vessels of this class:

Run.	Time.	Speed.	Mean revolutions.	Steam pressure.
	Min. s.	Knots.	Per minute.	Lbs. per sq. inch.
1.....	1 50.8	32.491	394.0	222
2.....	1 58.6	30.354	394.9	227
3 ^a	1 48.4	33.210	407.4	230
4 ^a	1 56.8	30.822	398.5	235
5.....	1 49.0	33.027	406.5	235
6.....	1 58.6	30.354	390.5	235

^a It will be seen that the mean of runs 3 and 4 is over 32 knots, so that the *Shirakumo* is one of the fastest vessels in existence.

True mean speed, 31.819 knots.

True mean revolutions, 400.8 per minute.

The vessel proved a good sea boat and notably free from vibration.

ASASHIO.

The torpedo-boat destroyer *Asashio* underwent a successful trial on April 24, 1902. The speed attained as a mean of six runs on the measured mile was 31.057 knots. The mean revolutions of the main engines were 381.4 and the horsepower 7,224. The mean speed for the three hours' run was 31.038 knots.

RUSSIA.

POBIEDA.

The battleship *Pobieda* had her six-hour trial trip under full steam October 19, 1901. In order to make up for the lacking weight represented by armor and armament, the ship took water ballast so that the draft was brought to 24.9 feet forward and 25.6 feet aft. The results of the trials were as follows: I. H. P.—starboard engine, 5,198; midship engine, 5,245; port engine, 5,049; total, 15,492. This was almost 1,000 horsepower above contract requirements (14,500 I. H. P.). The speed attained was 18.5 knots in an average of four runs over the measured mile. The boilers and engines worked satisfactorily. The coal consumption of the thirty Belleville boilers was 2.6 pounds per unit of horsepower per hour.

RETWISAN.

The battleship *Retwisan* had her trials October 21, 1901, with the following result:

Draft of the vessel: Forward 24 feet 3 inches; aft, 25 feet; mean, 24 feet 7.5 inches. Length of measured distance, 10 knots. Wind northwest; force, 3; sea, calm.

Number of run.	Elapsed time.	Speed.	Revolutions.	Steam pressure on boilers.	Indicated horse-power.	Per cent of slip.
October 21.	Min. s.					
1	33 38	17.84	118.92	253	14,032.95	20.11
2	34 27	17.42	118.98	248	14,064.54	22.11
Average		17.63	118.95	250.5	14,048.74	21.11
3	37 47	15.88	99.60	201.5	7,227.21	15.23
4	38 55	15.42	100.20	198.5	7,379.20	18.15
Average		15.65	99.90	200	7,303.20	16.69
5	58 12	10.31	62.76	204	1,711.07	12.40
6	58 27	10.27	63.09	207.5	1,775.57	13.30
Average		10.29	62.92	205.75	1,743.32	12.85
October 22.						
7	33 41	17.813	126.12	251	17,123.91	24.69
8	33 00	18.182	124.91	254	17,099.51	22.47
Average		17.998	125.52	252.5	17,111.71	23.58

Before beginning run No. 7, October 22, the vessel was brought down to the draft given at the head of the table.

The full-speed trial, lasting twelve hours, was begun on October 22 and finished on October 23. The steam pressure was 242.95 pounds.

	Average revolutions.	Vacuum.	Indicated horse-power.	Average speed.
Port engine	124.79	24.7	8,340.42	.....
Starboard engine	123.07	23.36	8,007.80	17.915
Total			16,348.22	.....

The coal consumption per I. H. P. per hour was 1.88 pounds.

The twenty-four-hour 10 knots endurance trial showed a coal consumption of 61.43 tons, the full-bunker capacity of the battleship being 2,250 tons.

The coal consumption at 15 knots speed was 1.37 pounds per I. H. P. per hour, 8,403.432 I. H. P. being developed for that speed.

BOGATYR.

At her builder's trials, this cruiser, of 6,500 tons, made an average speed of 24 knots, her engines developing 20,500 horsepower.

DIANA.

This cruiser had her trials on November 12, 1901, at which time she ran for six hours at full speed. It was found that she only drew 20 feet 10 inches on an even keel, showing that her displacement was 6,660 tons, or 70 tons less than she was designed for. Her three engines together developed 12,129 horsepower, or 519 horsepower more than contracted for. The speed attained was 19.3 knots.

PALLADA.

The cruiser *Pallada* made a six-hour trial trip, under forced draft, November 3, 1901, for the purpose of testing her engines, furnished by the Franco-Russian Works. The results of the trial were I. H. P., starboard engine, 4,543; midship engine, 4,405; port engine, 4,152; total, 13,100, or 1,500 more than required under the contract (11,600). Instead, however, of the 20 knots required, the cruiser made only 19.2. The 24 Belleville boilers worked satisfactorily; but toward the end a group of four boilers had to be cut off, owing to the leaking of a feed valve.

NOVIK.

This second-class protected cruiser, which is described on page 97, General Information Series, No. XX, has been having her trials, but the published data are meager and conflicting. At a trial held on July 18, 1901, she is said to have made an estimated speed of 26 knots, and later in the year it is claimed she made an average speed of 26 knots, under forced draft, while running in a gale with a heavy sea. Other reports state that after 12 separate speed trials she has been unable to maintain the guaranteed speed of 25 knots for ten consecutive hours, the longest period at that speed having been two hours, her average speed being 21 knots.

FILIN, GAGARA, NYROK, SOVA, VORON, AND YASEB.

These torpedo-boat destroyers, of the *Sokol* type, 240 tons, have had their speed trials.

The *Filin*, built at the Newski Works, made 26.94 knots, under forced draft, October 10, 1901. On a four hours' trial, with nine-tenths of her full power, a maximum speed of 24.5 knots was made.

The *Gagara*, built at Newski, had her trials over the measured mile, August 15, 1901, and made 27 knots. On a four hours' trial, with nine-tenths of her full power, she averaged 25.54 knots.

The *Nyrok*, built at Ijora, made 26.18 knots on her acceptance trial, October 10, 1901. The required speed was 26.5 knots. Further trials had to be postponed on account of an accident to the low-pressure cylinder.

The *Sova*, built at the Newski Works, made 26.81 knots, under forced draft, October 17, 1901. On a four hours' trial, at nine-tenths full power, a maximum speed of 24.5 knots was made.

The *Voron*, built at Newski, made a run over the measured mile, attaining a speed of 28.1 knots with 432 revolutions.

The *Yaseb*, built at Ijora, made two runs over the measured mile with an average speed of 26.84 knots. On her four hours' trial, under full steam, she made 26.5 knots with 352 revolutions.

SWEDEN.

DRISTIGHETEN.

This armored coast-defense vessel, of 3,500 tons, has completed her trial trips. In a long run, under forced draft, she attained a speed of 17 knots.

1300—02——5

SECTION IV.
RECONSTRUCTION OF OLD SHIPS.
ENGLAND.

ROYAL SOVEREIGN CLASS.

The 6-inch guns on these battleships are to be put in casemates.

BARFLEUR AND CENTURION.

All the 4.7-inch R. F. guns on these battleships will be taken out and replaced by 6-inch R. F. guns in casemates. The armor plate for the casemates will vary in thickness from 2 to 6 inches.

POWERFUL AND TERRIBLE.

Four 6-inch R. F. guns, in casemates, will be added to the armament of these cruisers. At the present time they have twelve 6-inch guns, four on each side, in casemates on the main deck, and two others in casemates on the upper deck, placed over the guns which are furthest forward and aft. The four other 6-inch guns are to be placed, two on each side of the upper deck, also in casemates, superposed upon those of the guns which occupy a position amidships on the main deck. This modification will add very greatly to the offensive power of these cruisers, which, in addition to the 6-inch battery, carry two 9.2-inch guns and thirty 12-pounder and smaller guns. When the modification has been made, the *Powerful* and *Terrible* will somewhat resemble the ships of the *Drake* class, but will, of course, lack the protection which will give these latter much greater value.

ARROGANT AND TALBOT CLASSES.

The 10 cruisers of the *Arrogant* class, 5,750 tons, and the 3 of the *Talbot* class, 5,600 tons, are to have the 4.7-inch R. F. guns replaced by 6-inch.

TORPEDO GUNBOATS.

The *Gossamer* has just been entirely refitted by Palmer's Shipbuilding and Iron Company, of Jarrow. She is a vessel of 735 tons displacement, and was built at Sheerness in 1890. Her original engines indicated 3,600 horsepower, but these have been taken out and twin-screw high-speed engines, having cylinders 19 inches, 29½ inches, 46 inches by 18 inches stroke, have been fitted, together with four water-tube boilers of the Reed type in place of the old locomotive boilers. This new machinery will give very nearly double the power on the original weight, and, as the result of her preliminary

trial proves, will increase the vessel's speed by about three knots—a decided improvement. The ship was taken to sea on March 6, 1902, for a full speed preliminary trial, and the results were very satisfactory, the machinery being run for three and three-fourths hours, a mean speed of 22 knots per hour over the measured mile being obtained. The *Skipjack* and *Speedwell* were converted in a similar manner by the Palmer's Company a short time ago, and quite recently the Government has placed an order for carrying out similar work to the *Jason* and *Circe* with the Fairfield Company. The *Niger*, a sister ship to the *Gossamer*, is also at Jarrow, being fitted with new machinery, and will be ready for her trials shortly.

On May 12, 1902, the *Gossamer* finished a full power trial, during which she developed an I. H. P. of 6,058 and maintained an average speed of 20.32 knots.

FRANCE.

DEVASTATION.

The work of reconstructing this old battleship is nearly complete. The new battery consists of four 10.8-inch guns of the latest model, mounted on the main deck in a central citadel, two 9.4-inch guns on spar deck, in central pivot mounts, and protected by shields, and ten 4-inch R. F. guns on the spar deck without protection.

The armor at the ports of the 10.8-inch guns is beveled, and the pivots of the mounts being at the side, the sides of the ports come close to the guns. The exposure in a fore-and-aft direction is, therefore, slight, but the vertical opening is very large.

COURBET.

The following table shows the changes made by the reconstruction of this old battleship:

	Before reconstruction.	After reconstruction.
Displacement, tons.....	10,200 (nominal)	10,800.
Guns in battery.....	Four 12.6-in.	Four 10.8-in.
Guns in bow	One 10.8-in.	One 6.4-in.
Guns in stern	One 10.8-in.	One 9.6-in.
Guns over battery	Two 10.8-in.	Two 9.6-in.
Guns, upper deck	Six 5.5-in., two 3-pdrs., twenty 1-pdrs..	Ten 4-in., fourteen 3-pdrs., seventeen 1-pdrs.
Torpedo tubes.....	Five above water.....	Five above water.
Broadside fire.....	Two 12.6-in., three 10.8-in., three 5.5-in., one 3-pdr., ten 1-pdrs.	Two 10.8-in., two 9.6-in., five 4-in., seven 3-pdrs., nine 1-pdrs.
Bow fire.....	Two 12.6-in., three 10.8-in.	Two 10.8-in., two 9.6-in., one 6.4 in.
Stern fire.....	Two 12.6-in., three 10.8-in.	Two 10.8-in., three 9.6-in.
Engines.....	Compound vertical three-cylinder ...	Same as before.
Boilers.....	Cylindrical.....	Belleville.
Indicated horsepower..	8,100	8,500.
Speed	15.1 knots.....	15.3 knots.

No change of importance has been made in the *Courbet's* armor, which is still her weak point. The belt is from 15 inches to $8\frac{3}{4}$ inches of iron, with $3\frac{1}{4}$ inches of compound deck on top of it. This deck is composed of a 2-inch iron deck with a $1\frac{1}{4}$ -inch steel deck laid over it. The redoubt is $9\frac{1}{2}$ -inch iron, with, as in all old ships, huge ports. To lessen the danger of these ports, $4\frac{1}{2}$ -inch hardened steel shields have been fitted to the 10.8-inch guns.

COETLOGON, TROUDE, and FORBIN.

The French minister of marine has decided that extensive alterations and repairs shall be carried out on these three cruisers, which belong to the reserve and are stationed, the first at Lorient, and the two others at Rochefort. They were built at Bordeaux more than ten years ago, and have never been good for anything, only one of them, the *Troude*, being fit to put out to sea. The alterations will include the renewing of the boilers, the replacing of the wooden decks, and the modernizing of the artillery. It is expected that the alterations, which will be very expensive, will render the vessels seaworthy and of some value as warships.

GERMANY.

SIEGFRIED CLASS.

The coast-defense ironclads *Beowulf*, *Hildebrand*, and *Heimdall* have been lengthened and the work hastened to completion, in order that they may take part, together with the *Hagen*, in this year's fleet maneuvers, thus forming a division of four homogeneous ships. A description of the changes made in these ships is given on page 149, General Information Series No. XX.

BRANDENBURG CLASS.

The budget for 1902 contains an appropriation for rebuilding the four battleships of the *Brandenburg* class. Some particulars of the alterations these ships are to undergo have been published. These concern the structure and armament of the vessels, as well as a renewing of the old worn-out boilers. All the wood in the vessels will be replaced, as far as possible, by steel, which will be used, among other things, for the berths, chests, drawers, and tables. The trial of unflammable wood on some of the German warships has not proved satisfactory, as it is found that after a time it rots and falls to pieces. Considerable changes will be made in the ventilation, which was found to be very much wanting in the expedition to China, in which the ships of the *Brandenburg* class took part, and a cold-storage plant will be installed. When they were designed, the submerged torpedo tube was in the experimental stage, and all the tubes in these ships were

placed above water; even those in the bows, which in older ships had been submerged, were placed above water for fear that they would otherwise interfere with the efficacy of the ram. In the transformed ships, all the torpedo tubes will be submerged, in spite of the improvements in mounting the above-water torpedo tubes, which enable them to be moved through a wide angle horizontally. The protection afforded the submerged tube is supposed to more than counterbalance the horizontal mobility and the power of thus changing the direction of discharge. The cost in connection with the alterations of the torpedo armament will alone amount to \$224,000 for each ship.

ITALY.

The movement against expensive reconstruction of old ships and in favor of devoting the available funds to the construction of new ships instead appears to have been successful. The plan of rebuilding the obsolete battleships *Duilio* (launched 1876), *Italia* (1880), and *Lepanto* (1883) has been abandoned. The reconstruction of the *Dandolo* (1878), which has cost about \$2,000,000, and on the results of which the rebuilding of the others was to depend, has not transformed her into a battleship answering modern requirements.

PORTUGAL.

VASCO DA GAMA.

This coast-defense ironclad, built at Blackwall, England, in 1875, is to be lengthened 23 feet 8 inches at the works of Orlando Brothers, Leghorn, Italy.

SWEDEN.

SVEA, GOTA, AND THULE.

The three coast-defense battleships, *Svea*, *Gota*, and *Thule*, built during the period from 1886 to 1892, which are being remodeled, will be completed during the spring of 1902. In place of the former armament of two 9.8-inch guns in a forward turret, and four 6-inch guns in unprotected positions, they will have an 8.3-inch gun forward, three 6-inch guns in each broadside, and a 6-inch gun aft, all rapid-fire, and each in a separate armored turret. Also eleven 2.24-inch R. F. guns on the deck and bridges. The cost of remodeling the three ships amounts to \$1,318,560.

TURKEY.

MESSOUDIEH.

The reconstruction of this battleship has been completed at the Ansaldo works in Genoa.

Among the changes have been the substitution of twin screws for

the old single screw. With a vessel not intended for twin screws, the attachment of the stern brackets to a stern not specially strengthened and constructed to receive them is likely to be a source of weakness, necessitating a stiff covering being fitted to the shafts, carried from the V-brackets to the after ring of the stern tube, so as to tie them firmly to the hull and prevent fore-and-aft motion. In the case of the *Messoudieh*, advantage has been taken of the existing screw opening to bring the propellers close together, thus reducing the leverage as much as possible. The stern brackets have an extra breadth of base attachment to the hull, and their weight and that of the stern shafting being well supported by the flange of the $\perp$ -shaped bar at the bottom of the stern frame, a very rigid structure is the result, and it was possible to dispense with the covering in of the shafts without fear of any undue vibration, or fore-and-aft movement of the V-frames.

Both the inner and outer bottoms were found to be in most excellent condition, and the vessel was so thoroughly well built (by the Thames Iron Works, in 1874) and of such excellent material, that she will be a most serviceable ship, and good for many years of service.

The new propelling machinery consists of two sets of triple-expansion four-cylinder inverted engines of 11,000 horsepower, the steam being provided by 16 water-tube boilers of the Niclausse type, arranged in four groups of four boilers each. Both engines and boilers have been constructed by Ansaldo, and it is noteworthy that this is the first set of machinery constructed in Italy the material of which (with the exception of the large shafts and the boiler tube) has been forthcoming in the country itself, the cast and malleable steel, and the malleable cast iron being furnished by Ansaldo's new steel works, and the special bronzes from their yellow metal works, both situated at Cornigliano, Ligure.

The armament is by Messrs. Vickers, Sons & Maxim, Limited, and consists of two 9.2-inch wire guns of 45 calibers, breech-loading; twelve 6-inch wire Q. F. guns of 45 calibers, breech-loading; fourteen 3-inch Q. F. guns; ten Q. F. 6-pounders; and two 3-pounders, besides two light boat guns, complete, with their carriages.

The 9.2-inch guns are mounted on a revolving platform on the upper deck, carrying a complete shield of hardened steel armor, 6 inches thick at the front and 3 inches at the back and sides. The twelve 6-inch guns are placed in the citadel, and mounted on central pivot carriages carrying a semicircular shield of hardened steel of armor $4\frac{1}{2}$ inches thick, which completely closes the gun aperture.

In April, 1902, the *Messoudieh* had her trials under natural draft, at Genoa, when an average speed of 17.5 knots was maintained, with 102 to 108 revolutions.

SECTION V.

COALING RECORDS.

ENGLAND.

CHANNEL FLEET.

At Gibraltar, during the week ending September 21, 1901, the following ships coaled in competition, all ships completing to full stowage with the exception of the *Resolution*. The last 100 tons, being difficult to stow, reduced the average:

Name of ship	Number of tons stowed.	Average tons per hour.	Name of ship.	Number of tons stowed.	Average tons per hour.
Majestic.....	821	113.78	Resolution	200	71.85
St. George	900	102.85	Repulse	1,000	71.42
Hannibal.....	830	102.68	Furious.....	840	60.00
Jupiter.....	895	94.21	Arrogant	470	57.55
Mars.....	896	91.89	Minerva.....	295	51.60
Magnificent	880	83.14	Pactolus.....	400	37.20

CRUISERS.

The *Indefatigable*, at Halifax, took in 403 tons of coal in five and one-half working hours, an average of just over 73 tons per hour. This she claimed as a record for her class of cruiser. The *Tribune*, a sister ship, claims to have taken in 420 tons in three hours and fifty minutes, average 109; 227 tons in two hours and twenty-five minutes, average 94, and 422 tons in three hours and forty-nine minutes, average 110. This is something like a record for cruisers of any kind, 100 to 110 being a fine performance for a first-class cruiser. In April, 1902, the cruiser *Terrible*, belonging to the China Squadron, claimed to have taken in 2,500 tons of coal in nine and one-half hours, an average of 263 tons an hour. The coal was landed on the ship's deck by 600 coolies. The ship's force put it below and stowed it.

MAGNIFICENT.

The *Magnificent*, battleship, coaled at Devonport from four colliers, and surpassed all previous records for this ship by embarking 1,838 tons of coal in less than fourteen working hours. The largest amount taken on board in a given hour was 200 tons.

CÆSAR.

The battleship *Cæsar*, of the Mediterranean Squadron, completed a very smart coaling operation in February, 1902, having taken in 1,477 tons in seven hours from lighters. Owing to an extra 27 tons having been sent, the average was 211 tons an hour; otherwise it would have been 223 tons. The largest quantity taken on board in any given hour was 260 tons, this being done twice.

COALING AT SEA.

During her cruise with the Reserve Squadron the battleship *Trafalgar* carried out some experiments for coaling warships at sea with the Temperley-Miller transporter.

When the fleet left Portland, the *Trafalgar* took in tow the collier *Muriel*, the apparatus having been fitted up on that vessel. At a speed of about 10 knots the course was altered several times to test the strain on the cable way, and then the coaling began. During this operation the squadron of 17 ships, in two lines, passed on either side of the *Trafalgar* and the *Muriel* to afford the officers an opportunity of witnessing the work, and a few days later the experiment was repeated. As it was not considered advisable to interfere with the programme of the cruise, it was not necessary to complete the coaling of the battleship, but the trial was rather intended to test the practical working of the machinery, and at each trial coal was transshipped at the rate of 35 tons an hour. When the squadron left Jersey, Vice-Admiral Noel directed the experiment to be made with the *Empress of India*, and the gear was transferred from the *Trafalgar* to that ship and expeditiously erected. The experiment was a highly practical one. As soon as the battleship had taken the collier in tow, the former steamed ahead at 10 or 11 knots, and during this part of the test she suddenly altered course 8 points, and the towing line and cable way answered so well that not a strand gave out. Coaling then took place, and 21 tons were transferred in thirty-three minutes, giving a rate of 40 tons an hour. There was a moderate sea and wind at the time.

FRANCE.

The official report recently published on the coaling operations of the French maneuver fleet in Toulon Harbor, August 11 to 14, 1901, is instructive and shows how important such exercises are as a preparation for actual war.

The French Squadron was to take on 15,000 tons of coal in all, namely, the battleships 7,800 tons, the armored cruisers 4,700, the small cruisers 2,250, and the torpedo boats 250. As the coaling operations were to take place under war conditions, the whole personnel of the Toulon Navy-Yard, all available tugs and lighters, and all

the apparatus in the harbor were placed at the disposal of the fleet, and the requirement was made that all necessary supplies, including provisions, were to be taken on board inside of three days. Moreover, Admiral Gervais, in order to stimulate the zeal of the men for this important operation, had issued a circular letter calling attention to the results attained in England in coaling warships, and mentioning particularly the performance of the *Majestic*, whose crew took in 1,070 tons of coal in five hours and seventeen minutes, or 203 tons an hour. This had the desired effect, for all the reports state that the conduct of officers and men was exemplary and that their efforts showed plainly their desire to come up to the English precedent. But, on the other hand, the operations demonstrated that the ships were not properly equipped for coaling and that the resources of the harbor were inadequate for that purpose. In the first place, the coaling scuttles of the different ships were not numerous enough and were too small in diameter, and the approaches of the coal bunkers too narrow and as inconvenient as possible. Temperley transporters were lacking entirely. The lighters had no machinery of any kind for conveying coal on board, so that the whole work had to be performed by hand. Besides, there were neither enough lighters nor coaling piers.

As the result of these conditions 7 coal lighters will be built at once, new cranes will be erected of a capacity of at least 3,000 tons, and a large number of coaling piers will be constructed, so that in future a squadron of 45 vessels will be able to coal in forty-eight hours.

It is but natural that under the prevailing circumstances the coaling proceeded but slowly, notwithstanding the zeal of the men, and that on an average not over 100 tons an hour could be taken on board by each ship. The best performances were those of the *St. Louis*, *Gaulois*, and *Masséna*, the first-named ship making the highest record, 160 tons an hour. To facilitate the coaling, an order was finally issued for part of the armored cruisers and all of the smaller vessels to go alongside the piers at the coal depot and to return to their respective anchorages as soon as they had taken their supply on board.

The following is a résumé of the results obtained by the battleships of the Mediterranean Squadron:

Vessel.	Quantity.	Time.	
	Tons.	h.	m.
<i>St. Louis</i>	500	3	0
<i>Gaulois</i>	450	2	56
<i>Masséna</i>	450	3	10
<i>Jaureguiberry</i>	450	4	0
<i>Bouvet</i>	500	4	10
<i>Charles Martel</i>	500	4	12

Of the Northern Squadron, the coast defense battleship *Bourviens* heads the list with 140 tons.

The operations referred to, owing to the above-mentioned inadequate conditions, could not be completed within the time specified; an additional day had to be used to take provisions on board.

GERMANY.

On April 11, the battleship *Kaiser Barbarossa*, while coaling, took on an average of 280 tons an hour. This performance establishes a new record.

SECTION VI.

MARINE CASUALTIES.

CHINA.

Kai-Chi.—The Chinese cruiser *Kai-Chi* was destroyed, while in the Yangtze River, by an explosion in the magazine, on June 21, 1902. One hundred and fifty officers and men were drowned.

DENMARK.

Moen.—During some experimental firing with a new shell containing a high explosive, carried out on the Danish gunboat *Moen*, in the Sound, on September 30, 1901, an explosion occurred. The vessel sank immediately. There was no loss of life, as the whole crew of the *Moen* had previously been, as a precaution, transferred to another ship.

ENGLAND.

Irresistible.—About 2.30 o'clock on the morning of March 3, 1902, during a thick fog, when the battleship *Irresistible* was off Beachy Head, lights were seen ahead and the *Irresistible's* engines were reversed. The strange ship followed suit, but they could not clear. The *Irresistible* struck the other vessel on the starboard side, denting several plates, while some of her own deck gear was carried away. The vessel, which proved to be the Dutch cargo boat *Clive*, from Cherbourg to Rotterdam, was apparently not seriously hurt, for she signaled she was able to go on without assistance, asking if the *Irresistible* wanted help. The vessels then proceeded and the *Irresistible* came on to Portsmouth to make good defects.

Formidable.—On April 28, 1902, while hoisting in boats, on the battleship *Formidable*, the 5.5-inch wire topping-lift of the main derrick jumped out of a 10-hundred weight iron snatch block, and swept across the deck, killing the gunnery lieutenant and a petty officer.

Mars.—On April 15, 1902, while at gun practice, a misfire took place in both the forward 12-inch barbette guns of the battleship *Mars*. Orders were given to use the auxiliary firing circuit. Four minutes later an explosion took place in the port gun by which the breechblock was blown to the rear, the projectile remaining in the gun. The starboard gun remained unfired. Two officers and nine men were killed; a midshipman, and 6 petty officers and seamen were injured.

Amphitrite.—While homeward bound, the cruiser *Amphitrite* went ashore in Suez Bay on February 7, 1902, but was floated with the tide next day and entered the canal.

Condor.—The sloop *Condor*, which left Esquimalt and was due at Honolulu December 15, 1901, has not been heard of since. Floating wreckage has been picked up along the coast of British Columbia, and it is supposed that the ship foundered in that vicinity.

Euryalus.—In order to make good the damage caused by fire while alongside a jetty at Barrow-in-Furness the first-class cruiser *Euryalus* was sent to Birkenhead to be docked. The dock in which the vessel was placed not being sufficiently long to receive her, temporary gates had to be built up in place of the ordinary caisson in order to give the required length. This work could only be performed at low water. To insure the ship remaining on the blocks at high water while the dam was being built, the whole of the double bottom of the ship and other parts were flooded with more than 2,000 tons of water. On the morning of August 7, 1901, a tremendous crash was heard which shook the whole works, and the *Euryalus* was seen to slide as if she were being launched, the blocks upon which she was resting apparently turning over. The vessel had dropped nearly 4 feet to the bottom of the dock and had moved about 6 feet to seaward. A survey of the damages showed that all her boilers must be taken out, that the vertical keel was greatly distorted, that all the inner and outer bottom, plating and frame, from the stem to the engine room, must be renewed, that a new wood keel was necessary, and that the bottom sheathing must be removed and refastened.

Crescent.—The first-class protected cruiser *Crescent* stranded on some sands near Antigua, West Indies, January 13, 1902, but was floated again without damage.

Indefatigable.—The cruiser *Indefatigable*, a vessel of 7,000 tons, was aground on the rocks near Quebec, Canada, September 18, 1901, at low tide. She got off at high tide, and, as she was reported to be leaking badly, she was ordered into dry dock at Quebec for repairs.

Mersey.—The cruiser *Mersey* left Sheerness July 17, 1901, to undergo an hour's steam trial, but stranded near the Nore. She was floated without assistance.

Egeria.—The British gunboat *Egeria*, while engaged in searching for the *Condor*, was ashore at Clayoquot, British Columbia, but afterwards got off undamaged.

Cobra.—The new torpedo-boat destroyer *Cobra*, built by Messrs. Armstrong, Whitworth & Co., at Elswick, and engined by the Parsons Marine Steam Turbine Company, while proceeding from the Tyne to Portsmouth, foundered in the North Sea on September 18, 1901. She was in command of a lieutenant, who had under his command a navigating party of 54 men. There were also 25 other persons on board, includ-

ing the chief engineer of the Elswick yard and the manager of the Parsons Company. The only survivors were the chief engineer and 10 seamen of the *Cobra*, and 2 fitters in the Parsons works.

The *Cobra* buckled up and broke into amidships. The court of inquiry, convened to inquire into the cause of the *Cobra's* loss, came to the conclusion that she did not touch the ground nor meet with any obstruction, but that it was due to structural weakness. The court also found that the *Cobra* was weaker than other destroyers, and expressed regret that she had been purchased by the English Government.

Viper.—The torpedo-boat destroyer *Viper*, a 34-knot boat fitted with Parson's turbine machinery, was wrecked on August 3, 1901, while engaged in scouting duty during the fleet maneuvers. She ran on Renonquet Rock, near Alderney, while in a fog, and became a total loss. The officers and crew were rescued.

Angler.—During the trials of the Medway destroyer instructional flotilla, on October 3, 1901, while the vessels were rounding the Tongue lightship off Margate, the 30-knot destroyer *Angler* and the 27-knot destroyer *Salmon* collided. Both vessels were able to proceed to Sheerness, where they were docked and the damages found to consist in the *Angler*, of a rent for about 6 feet on the starboard side, the side being broken through for about 1 foot, and one of her plates fractured, with slight damage also to stanchions and above-water fittings, while in the *Salmon* the damage was chiefly on the port side, she being bulged in for about 6 feet, one of her propellers being torn off and lost, and the other damaged. The damaged part of the *Angler* was about 2 feet out of water, but the indentation of the *Salmon* was just above the water line.

On October 30 the *Angler* was struck, during a strong gale off Harwich, by the Great Eastern Railway Company's steamer *Suffolk*. The steamer struck the *Angler* a sliding blow on her bow and seriously damaged her stem.

Crane.—On October 9, 1901, while the torpedo-boat destroyer *Crane* was on her way from Portsmouth to Portland, a buckling of the deck beams amidships was observed in the engine room. The ship was at once turned round and headed back to Portsmouth, where an examination was made which showed that in sagging between the waves the deck beams had been bent amidships. The general opinion of experts is that the injury was the result of an old defect rather than a new development.

Dragon.—The torpedo-boat destroyer *Dragon* collided with the gun-boat *Harrier*, October 19, 1901, and sustained damages to her bows and stem. The accident took place near Malta.

Electra.—During a thick fog, on October 23, 1901, the torpedo-boat destroyer *Electra*, forming a part of the reserve fleet then off the northeast coast of England, collided with an unknown vessel, and had her bows almost entirely shattered.

Fairy.—While taking up her moorings in the Hamoaze on September 28, 1901, a serious accident befell the torpedo-boat destroyer *Fairy*. She had secured her bow cable and was making fast to the stern buoy, when the *Vigilant*, another destroyer, ran into her, smashing the *Fairy's* cutter to pieces and knocking overboard a petty officer and several men, one of the latter receiving serious internal injuries. The *Fairy's* forequarter was dented, her port propeller guard smashed, and her port shaft bent. The mishap was attributed to the failure of the *Vigilant's* steering gear.

Ostrich.—When the torpedo-boat destroyer *Ostrich* was returning from the Hamoaze at Devonport, on October 17, 1901, she collided with the hulk *Monmouth*. Two of her funnels were knocked over, her anchor bracket was carried away, and a quantity of plating was stripped off the starboard bow. Very little damage was done to the *Monmouth*.

Porcupine.—When getting under way from her moorings at Greenhithe, on October 22, 1901, the torpedo boat *Porcupine* collided with the hospital ship *Egidia*, belonging to the training ship *Worcester*, and did extensive damage to her own stern and to the port quarter and side of the hospital ship.

Salmon.—The torpedo-boat destroyer *Salmon* collided with the *Angler* on October 3, 1901. For details, see *Angler*.

On the night of December 2, the *Salmon* collided with the Great Eastern Railway's Channel steamer *Cambridge*, off Harwich, Essex. Most of the crew of the *Salmon* got aboard the *Cambridge*, which succeeded in grounding the *Salmon* in a sinking condition. Later the *Salmon* was towed into Harwich by the Trinity steamer *Satellite*. One of her sides was stove in and her deck forced up.

Spiteful.—While with the reserve fleet, off the northeast coast of England, on October 23, 1901, the torpedo-boat destroyer *Spiteful* had a collision with the *Petrel*, twisting her stem and having her bows partly torn away. The *Petrel's* injuries were slight.

Star.—While entering Albert Harbor, near Greenock, on the night of September 15, 1901, the torpedo-boat destroyer *Star* struck the entrance and had her stem twisted.

Tiger.—The torpedo-boat destroyer *Tiger* had a collision off Scilly with the collier *Swiftsure* about July 24, 1901. All her bows were smashed in, and she had to be docked at Liverpool in order to make repairs.

Wizard.—A collision took place in Portsmouth Harbor on the night of September 10, 1901, between the torpedo-boat destroyer *Wizard* and the steamboat *Duchess of Albany*. The *Wizard's* stem was broken, and her bow so much indented that she had to be docked.

Another accident befell this ship during the first part of December. While steaming out from Portsmouth, she collided with a passenger steamer and was badly damaged. Her bows were stove in, but she managed to regain the harbor.

Vigilant.—The torpedo-boat destroyer *Vigilant* ran into the *Fairy* in the Hamoaze on September 28, 1901. For details, see *Fairy*.

Vulture.—The torpedo-boat destroyer *Vulture* returned to Portsmouth on October 12, 1901, with her decks buckled up through being caught in heavy seas. The buckling was on the upper deck, and fortunately the keel plate was not broken. The accident occurred outside the Needles.

Recruit.—During a dense fog on the morning of May 27, 1902, the torpedo-boat destroyer *Recruit* ran on the Venick Rocks, to the north of Cape Cornwall. Shortly after noon she floated off unaided, and was towed to Penzance by the tug *Triton* of Falmouth.

No. 14.—Torpedo boat No. 14 went aground on the Warden Ledge, near the Needles, during some searchlight operations on the night of September 12, 1901. The boat was lightened on the rock and towed into the harbor, where she was docked for repairs. Several of her ribs and rivets were started, but otherwise she was not seriously damaged. The accident was attributed to the lookout being unable to see ahead after remaining too long under the searchlight.

No. 81.—During the maneuvers on August 1, 1901, torpedo boat No. 81 struck the submerged ruins of Alderney Breakwater during low tide, sustaining serious damages, from which she sank after gaining the harbor and transferring her guns, ammunition, etc., to a freight steamer. Later she was successfully raised.

FRANCE.

Bouvet.—While the battleship *Bouvet* was maneuvering off Toulon, her main shaft broke and she was brought into port in a disabled condition.

Indomptable.—At the commencement of the trials of the *Indomptable*, after extensive repairs, she came in collision with an Italian schooner, in February, 1902. The collision was due to defective steering gear. The captain of the *Indomptable* is said to have declared that if the squadron had been in the harbor he would not have dared to try to leave the port, in consequence of her bad steering.

Triton.—A serious accident to the French submarine *Triton*, at Cherbourg, was reported in November, 1901. It appears that the vessel plunged too rapidly, struck the bottom and sustained considerable damage. Water began to flow in very rapidly, but the engineer ordered the detachable weights to be cast adrift, and the boat rose to the surface, though none too soon. The pumps were started, and a tug pulled the vessel into the arsenal.

Gustave Zede.—On April 30, 1902, during night attack exercise, the submarine *Gustave Zede*, which came out of Toulon to endeavor to torpedo the *Jauréguiberry* ran ashore. Her position was critical, but with the assistance of a tug she was refloated. She lost a torpedo and some portion of her under-water fittings.

No. 124.—In the course of the maneuvers off the coast of Corsica on the night of September 17, 1901, the French torpedo boat No. 124 was run into by another torpedo boat, No. 139, and sank an hour afterwards. The crew were all saved.

No. 164.—On May 4, 1902, torpedo boat No. 164, in leaving the arsenal at Cherbourg, ran against the pierhead of the outer harbor, and damaged her bow plate for a length of 6 feet. The accident was due to the parting of her wheel ropes.

No. 208.—On the night of September 28, 1901, a serious explosion took place on torpedo boat No. 208, which was out for practice. Orders had been given to force the fires. One of the firemen took a shovel, filled it with coal, and threw the coal into one of the furnaces. At the same instant another fireman opened the hatch leading to the deck. The inrush of cold air caused such a rapid change of temperature that one of the boiler tubes exploded. Five men in the fire room were badly scalded by the escaping steam. A petty officer died as soon as he was taken ashore.

No. 216.—In July, 1901, a collision took place off Toulon between torpedo boats No. 216 and No. 217. The former was hit amidships, above the machinery space, but the bunkers being full of coal the effect on the hull was weakened. No. 217 had her bow completely twisted. No. 216 made water very fast, but was rescued by No. 220, which towed her back to Toulon.

GERMANY.

Amazon.—On the morning of May 24, 1902, while cruising in the squadron, off the Irish coast, the battleship *Kaiser Wilhelm II* collided with the cruiser *Amazon* in a fog. The ram of the *Kaiser* struck the *Amazon* on the starboard bow, tearing open the side up to the rail. The broadside torpedo room was flooded, and some of the forward compartments injured. The *Amazon* remained with the squadron until they arrived off Heligoland, when she proceeded to Kiel for repairs.

Ariadne.—On July 11, 1901, while making speed trials under forced draft, an explosion took place in one of the forward boilers of the cruiser *Ariadne*. These boilers are of the Shulz-Thornycroft type, and have several hundred small tubes with an internal diameter of from 1.3 to 1.5 inches, and a thickness of from 0.13 to 0.15 inch. By the explosion 70 tubes were damaged, 39 tubes were blown out of the superheater, 26 were partially blown out, and 5 were blown in. Six men were injured by the explosion, two of whom subsequently died.

Ægir.—While the German coast-defense ship *Ægir* was about to get under way from her buoy in the harbor of Kiel, early on the morning of August 6, 1901, several tubes in a Thornycroft boiler exploded, and 5 men were injured, though none of them seriously. The *Ægir* pro-

ceeded immediately to the navy-yard. The boilers were comparatively new, and the cause of the accident was believed to be a lack of water in some of the tubes.

Blucher.—On the evening of March 2, 1902, the German school-ship *Blucher*, during a dense fog, ran against the bastion of the Flensburg wharf, and sank in consequence of the injuries received. No lives were lost, and the work of raising the ship was begun at once.

Kürfürst Friedrich Wilhelm.—While executing maneuvers under battle conditions in the outer harbor of Kiel on the evening of June 11, 1902, the *Kürfürst Friedrich Wilhelm* was assumed to have been put out of action, and was to be towed out of the battle line by the *Weissenburg*. The *Kürfürst Friedrich Wilhelm* had already stopped her engines, and was awaiting the approach of the *Weissenburg* to throw her a towline. The steering gear of the *Weissenburg* failed to work, and when the ships were about 20 yards apart it became evident that a collision was imminent. All of the water-tight doors on board the *Kürfürst Friedrich Wilhelm* were speedily closed, and the engines of the *Weissenburg* were reversed. The ram of the *Weissenburg* entered the plating of the *Kürfürst Friedrich Wilhelm*, and compartment 6 was instantly flooded. The injured ship heeled 3 degrees to port. The *Weissenburg's* ram was bent, and some water entered the collision bulkhead. Both ships were docked for repairs.

Wacht. The German cruiser *Wacht* collided with the battleship *Sachsen* during the fleet maneuvers September 4, 1901, and was sunk. All hands were saved. The weather was fine, but there was considerable sea.

It appears that the fleet was in double column, in two squadrons. The *Wacht* was acting as repeating vessel, and was on the port flank of the second or port column. The signal was made to change flanks. For this the second squadron had to pass through the ships of the first squadron, turning eight points to starboard first, and then resuming course when in new position on the starboard flank of the first column. The *Wacht* had to pass through the intervals of both columns in order to take her new position on the starboard flank of the second squadron, to which the *Wacht* belonged. The fleet was steaming probably at about 9 knots. Ships and columns were 328 yards apart. The *Wacht* passed through the intervals of the first squadron, but in trying to pass between the *Sachsen* and *Weissenburg* the steering gear failed, and she was struck by the ram of the *Sachsen* and sank in thirty-two minutes. The blow was on her starboard side, between the engine and fire rooms. The *Sachsen* at the time was turning to port to take the new course with the column of the second squadron on the starboard flank of the fleet. Both ships reversed engines when collision was imminent, but it was too late.

The steam-steering gear of the *Wacht* had been previously disabled

and temporarily repaired just before she left for Kiel for the maneuvers, but it failed again. At this time hand-steering gear was in use, and nine men sprang to the wheel, but they were not able to move the rudder more than 8 degrees.

The ship sank, bows first, in 25 fathoms of water, after the *Weissemburg* had started to tow her into shoal water on Adler Shoal, near the scene of collision.

No. 76. During the maneuvers, torpedo boat No. 76, of 150 tons and 25 knots, sank, taking down with her three men of the crew. Two of them were able to escape from the vessel, but the third was drowned.

S-32. On April 10, 1902, at 10 o'clock p. m., while the torpedo-boat division of the training fleet, S-8, S-32, and S-37, was proceeding to the eastern Baltic, S-32 collided with the schooner *Odin*, off the island of Moen. The schooner sank at once; her crew of three men was rescued and taken to Kiel. S-32 was considerably injured and has gone to the dockyard for repairs.

S-42. The German torpedo boat S-42 was run down and sunk by the British steamer *Firsby*, at the mouth of the Elbe, on the night of June 24, 1902. The night was somewhat cloudy, but there was no fog, and the lights of both vessels were burning brightly. The boat sank in about five minutes after the collision, and the commanding officer with three of the crew were drowned.

ITALY.

Andrea Doria. The Italian battleship *Andrea Doria* went ashore near Gallipoli on June 28, 1901, but was refloated July 3, without having sustained serious damages.

Stromboli. In July, 1901, the Italian cruiser *Stromboli* ran aground in the river about half a mile below the Cosmopolitan Dock, Shanghai.

Freccia. While endeavoring to enter Dover Harbor on the morning of August 13, 1901, the Italian torpedo boat *Freccia* came into collision with the Admiralty pier and sustained severe injuries to her stem and her plates below the water line. She was taken into the Granville dock to be repaired.

JAPAN.

Musashi. While at anchor at Nemuro, Hokkaido, on May 1, 1902, the Japanese gunboat *Musashi* parted her cables during a storm and was blown on the rocks. Her keel was badly damaged and her hold was soon filled with water. The crew were compelled to abandon her, and it is thought that it will be impossible to float her.

Yaeyama. While going to the assistance of the *Musashi*, the third-class cruiser *Yaeyama* ran aground off Nemuro and sank. When last reported her upper deck was awash, the crew had left the ship for a provisionary barrack ashore, and there was little hope of floating her.



PERESVIET. RUSSIAN BATTLESHIP, 12,674 TONS.

RUSSIA.

Peresviet. The cruiser *Peresviet* arrived at Cronstadt October 28, 1901, took on board 800 tons of coal, and sailed for Cherbourg from Kiel on October 31. She stranded on the northern extremity of the island of Langeland November 1, but was got off with assistance from a Svitzer steamer on the morning of the 2d, and continued her voyage for Nyborg and Cherbourg.

Forel. About November 28, 1901, the Russian torpedo boat *Forel*, while going from Kiel to Havre, grounded near Oste light-ship, but was got off without assistance. Her rudder was damaged.

SPAIN.

Condor. During the latter part of January, 1902, a boiler explosion occurred on board the Spanish gunboat *Condor*, causing the death of the vessel's two engineers and a seaman. The officers and men numbered 22, of whom 10, including the commander, appear to have been seriously injured. The two engineers were blown to pieces. The explosion is attributed to the bad condition of the boilers, which formerly belonged to a torpedo boat now out of commission, and the men had repeatedly protested against their use. At the time of the explosion the *Condor* was engaged in pursuing some fishing boats in the bay at Vigo, and had been compelled to put on extra pressure of steam.

Rio de la Plata. On August 26, 1901, at Bilbao, during a gale, the battleship *Pelayo* parted her cables from the violence of the wind and fouled the cruiser *Rio de la Plata*, causing her serious injuries.

II.

NOTES ON ORDNANCE AND ARMOR.

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Staff Intelligence Officer.

SECTION I.

GUNS AND MOUNTS.

MODERN NAVAL ORDNANCE.

The following interesting paper, a review of modern naval ordnance, read before the Institution of Mechanical Engineers by Lieut. T. A. Dawson, ordnance engineer of Vickers Sons & Maxim, is inserted at length. The illustrations are reproduced from the excellent cuts of Engineering.

Some of the gun mounts have been described in previous numbers of the publications of the Office of Naval Intelligence, but are again published to facilitate the reading of the paper.

The paper is an exposition of the present condition of the development of naval ordnance:

The urgent lesson taught by recent naval warfare is the clamant need for quick-firing, high-powered guns, well protected by armor of the highest resisting quality. There is no need to enforce the importance of long range; any ship with this advantage can "play" with a better or equally armored vessel having artillery of less power; and as to gun protection, it may be recalled that when the American ships attacked Cervera's fleet in their ill-fated rush from Santiago the Spanish crews were driven from their gun positions by a hail of 1 and 2 pounder shot, while the ships and their deck structures were pounded by the 6-inch quick firers and the larger breechloaders of their opponents. Had the Spanish gun positions been adequately protected, and their gunners enabled to continue fighting their weapons, there would have been a less one-sided contest. It is of vital importance, therefore, to consider the rapidity of fire and power of guns of several of His Majesty's ships, which, although constructed only a few years ago, are deficient owing to the recent great increase in the energy of guns. It is impossible to redesign these cruisers, but new guns of greater power and a higher rate of fire could easily be fitted at little cost, adding greatly to the fighting efficiency of the ships.

As an instance of the inferiority in gun power of some comparatively new cruisers

a comparison is made in Table I of the aggregate energy of the guns of H. M. S. *Diadem*, which was launched in 1896, just five years ago, and of H. M. S. *Hogue*, practically of the same size, now being fitted out. The basis of comparison is the most accurate one of the striking energy which the guns develop when utilized to the best advantage in a given time. For this comparison the velocities of the 6-inch guns of the *Diadem* and *Hogue* are assumed to be, respectively, 2,150 feet and 2,550 feet per second, giving energies at 3,000 yards range of 1,416 and 1,996 foot-tons, and the velocity of the 9.2-inch gun is 2,720 feet per second, representing an energy of 11,564 foot-tons at 3,000 yards. The rapidity of fire obtained is indicated in the table. The 12-pounder guns and those of less caliber are not included, as their power in determining the issue of an action at long range would be small. The result of the comparison is that the total striking energy of the *Hogue* is almost double that of the *Diadem*, 296,516 foot-tons against 158,592 foot-tons. This surely is a condition which calls for consideration, especially as it is but a fair representation of the increase in the power of the guns of to-day.

TABLE I.—Total energy per minute of the guns in two cruisers fighting at 3,000 yards range.

<i>On first-class cruiser Diadem, launched in 1896.</i>	<i>On armored cruiser Hogue, launched in 1900.</i>
Sixteen 6-inch guns, with a muzzle velocity of 2,150 foot-seconds, and firing at the rate of 7 rounds per minute, will give a total energy of 158,592 foot-tons.	Twelve 6-inch guns, with a muzzle velocity of 2,550 foot-seconds, and firing at the rate of 9 rounds per minute, will give an energy of 215,568 foot-tons.
	And—
	Two 9.2-inch guns, with a muzzle velocity of 2,720 foot-seconds, and firing at the rate of $3\frac{1}{2}$ rounds per minute, will give an energy of 80,948 foot-tons.
Total energy, 158,592 foot-tons.	Total energy, 296,516 foot-tons.

This comparison is made on the assumption that the service explosive—namely, cordite—is utilized; if, however, nitrocellulose powder were used in the more modern guns of H. M. S. *Hogue*, which are equally well designed for its use, and would have a much longer life, notwithstanding the increased energy, the twelve 6-inch guns would then have a velocity of 2,800 foot-seconds, and, firing at the same rate, would give an energy of 259,740 foot-tons; and the two 9.2-inch guns would have an energy of 91,966 foot-tons, firing at the same rate and with a velocity of 2,900 foot-seconds. The total striking energy of the *Hogue* would thus become 351,706 foot-tons, as against 158,592 foot-tons of the *Diadem*.

THE STRUCTURE OF GUNS

In figs. 1 to 6 there are illustrated for general purposes of comparison various types of British and foreign guns of strictly modern design. Two general systems of construction are adopted by most naval powers. In the one the gun is entirely of steel and in the other of steel and wire. Great stress can not be laid on the advantages of one system over the other. At the same time the author is of opinion that by the proper application of wire the highest possible efficiency in construction can be obtained, owing to the greater possibility of varying the tension of the wire and tubes with greater theoretical accuracy than is possible with solid steel construction. Steel as wire is much the strongest form of this metal. Moreover, the wire winding gives higher resisting radial strength to the gun, and this is of great value in the event of a premature bursting of a high-explosive shell in the bore. On the other hand, the wire-constructed gun is more expensive in manufacture, but this is not of much consequence provided the best results are obtained.

The wire-wound gun.—The diagram of the 12-inch 40-caliber gun of British type

NITRO CARTRIDGES		
CHARGE 150 grains	707165	251285
WGT. CARTRIDGE	610	615
WGT. CARTRIDGE per 1000	3800	2840
WGT. CARTRIDGE	66239.	62100



CROCODILE		
CHARACTER	22 10 5	40 5 10
PROJECTILE	430	200
VELOCITY - 1000 ft/sec	200	200
WIND - 1000 ft/sec	100	100



15 THIRTY SEVEN FOUR FIVE



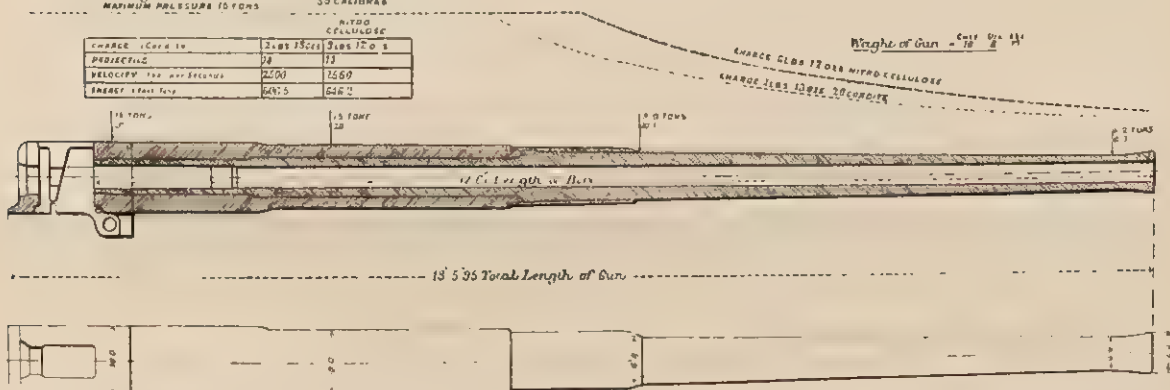
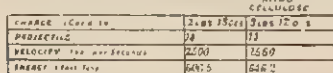
ORDNANCE BL 6 INCH WIRE 50 CAL (Type Japanese)



14 1/2" 45 CALIBRE Q F. GUN (Type Spanish)



Rq 6 3 INCH (1909) AUTOMATIC Q P GUN Type United States of America





(fig. 1) clearly shows the construction of a typical wire-wound weapon and the disposition of the wire and tubes and other general details; there are added curves showing the pressures in the bore on the explosion respectively of nitro-cellulose and cordite charges. This method of construction—with one tube inside another, extending the whole length of the gun—admits of rapid and efficient repair when the inner tube is worn out as a result of a number of rounds having been fired. The radial strains on firing are overcome by the shrinkage of the A tube of the gun upon the inner tube, and by the wire being wound at varying tensions. The longitudinal strains are taken by the large sections of the A tube and jacket being connected by a breech ring. The construction of this gun is practically similar to the 7½-inch 45-caliber gun shown on fig. 3, where also dimensions and curves of pressure are included.

Other general types of wire-constructed guns are shown by fig. 2, illustrating the 9.2-inch breech-loading gun designed and constructed by Messrs. Vickers, Sons & Maxim, Limited, for the Turkish Government, and by fig. 4, showing the 6-inch 50-caliber gun now being manufactured by the same firm for the Japanese Government. It will be seen by reference to these diagrams (figs. 2 and 4) that the wire only extends for about one-half the length of the shot travel, the radial strains in the chase being taken by a solid steel hoop shrunk over the inner tube. In guns of 50 calibers length the elimination of the wire over the chase enables the girder strength to be somewhat improved, so that there is no fear of the extra length causing the gun to droop.

The steel-constructed gun.—A general type of steel-constructed gun is shown in the diagram (fig. 5), illustrating the 14-centimeter 45-caliber gun. It consists of an inner and outer A tube extending the whole length of the gun, reenforced by a jacket and breech ring. The inner is put into the outer A tube with a taper of 1 in 500, with a suitable amount of shrinkage to insure the best constructional effects.

Nickel steel v. wire winding.—Messrs. Krupp, who have done so much for the improvement of ordnance generally, use nickel steel for all the tubes except the inner. The use of nickel steel instead of ordinary steel has no doubt some advantages, notably greater strength of material; but this high quality of steel is not so necessary with wire-wound guns, owing to the extra strength given by the wire far exceeding that of any ordinary nickel steel. There is much in favor of using a steel giving a high elastic limit and good elongation for the smaller types of guns, for which the wire system is perhaps less suited. By using suitable steel and treating it by a special process the necessary strength can be obtained without the addition of nickel.

The construction adopted with small guns.—Another type of steel gun to which reference may be made is the 14-pounder automatic quick-firing gun adopted by the United States of America, illustrated by fig. 6. The small charge used by this gun does not render it imperatively necessary to reenforce the chase, but the A tube of the gun is made of the best quality of steel and suitably treated to perform its proper functions. The jacket of the gun, which also carries the mechanism, is shrunk on from the breech end, and is locked to the A tube by a second hoop. This construction is largely adopted for guns of small caliber, and is especially applicable where the breechblock works in the vertical plane.

THE BREECH-BLOCK AND OBTURATOR.

The systems of breech-loading utilized with modern naval artillery are very varied, but may generally be divided into two:

Firstly, those utilizing screw mechanisms, in which the longitudinal strain on firing is conveyed through the breech screw to the outer construction of gun, the gases being sealed by some well-known device; and

Secondly, the wedge or block form of mechanism, in which the longitudinal strain of firing is taken up by a block of steel of general construction worked by some

suitable mechanism for opening or closing the breech, the gases being sealed by means of a metallic case.

The wedge system of mechanism is that generally adopted by Messrs. Krupp, although they also utilize the breech-screw system in some of their guns.

Screw v. wedge plug.—The only serious advantage which can be claimed for the block or wedge type of mechanism is that, generally speaking, it is simpler in construction, but it necessitates a continuation of the gun tubes beyond the breech end, and as this projection is otherwise noneffective the extra weight counterbalances the advantage of simplicity. The wedge system has been adopted generally in Germany and Austria and many of the smaller countries of Europe and South America. The breech-screw form is much more generally utilized, having been accepted by Great Britain, France, the United States, Russia, Spain, Italy, etc. Indeed it may be considered the best form of breech-closing device at present in use, and its general features may be referred to.

The design of the screw mechanism depends principally on whether it is desired to utilize a metallic-case obturator or the plastic-pad system. In both cases, however, the form of breech screw used is to a great extent a governing factor, and is of great importance. The type of screw invented by Mr. Axel Welin, a Swedish engineer, is the one at present mostly used in modern artillery mechanisms, the British Government having generally adopted it, as well also as the United States of America, while several other countries have equipments now under experiment. It is shown by fig. 7. The construction of the screw is such that in the case of the 12-inch mechanism three-quarters of the circumference can be utilized as threaded surface, leaving one-quarter only noneffective for taking up the backward thrust due to the explosion of the propellant in the gun chamber. In the case of the 6-inch breech screw two-thirds of the circumference can be screwed, and one-third only is thus noneffective. The length and weight of the plug for a given resistance can thus be reduced, effecting a still greater saving in the weight of metal at the breech end of the gun, while there is great advantage in the general arrangement of the mechanism, owing to the shorter screw. The author has experimented with this screw in connection with a 15-pounder field gun, firing the gun with the breech rather more than half open; the portion of the screw in bearing (rather less than half the ordinary shearing section) proved sufficient to hold it in place, even under proof pressure, and no damage to the mechanism resulted. This experiment showed the great strength, utility, and efficiency of this form of screw, while great saving in weight is effected. Thus the breech screw of the 6-inch gun of this improved type (fig. 7) weighs 116 pounds; the parallel screw for the same caliber gun (fig. 8) weighs 178 pounds, and the type of screw partially coned and partially parallel, for the same strength (fig. 9) weighs about 212 pounds. The saving effected in the Welin form over the ordinary parallel form is at least 35 per cent in the breech screw alone, and a great deal more in the annulus of steel forming the rear portion of the gun into which the screws gear. A long series of experiments conclusively proved that this form of screw is the best at present utilized for breech mechanism, either of the De Bange obturator type or of the more usual form of metallic-case system of obturation.

Metallic v. plastic pad obturation, etc.—A discussion of the advantages of one system of obturation over another must necessarily be of a very technical character, and might of itself form the subject of a special paper; it can only be briefly referred to here. In guns making use of a metallic-case system the weight of the case is a very serious objection, especially when using the very large charges necessary to obtain the highest possible ballistic imperatively necessary in connection with modern artillery. In order to obtain a velocity of, say, 2,900 feet per second in a 6-inch gun, a charge of powder has to be used of from 30 to 35 pounds, according to the nature of the explosive. Such a charge entails the use of a very large case, whose weight is equal to that of the charge. Now, if it be assumed that for each 6-inch gun on board

ship there would be 200 charges, the cases alone would weigh rather more than 3 tons per gun. In the *King Alfred* class of cruiser there are 16 of these guns on board, so that the aggregate addition to weight for cases alone is 48 tons. There is, moreover, the other serious disadvantage with the metallic-case system of having to extract the heavy and cumbersome case from the chamber after each shot is fired, and of storing it or throwing it overboard. The objections to the case systems are: (1) The rate of fire is considerably reduced owing to the necessity of handling very heavy cartridges and of withdrawing the case after firing; (2) there is a chance of failure of the case, which, when it occurs, puts the gun out of action; (3) the extra weight necessary to be carried on board ship.

All these disadvantages are overcome by the use of a suitable plastic pad form of obturation, an efficient form of which has been evolved, after much experiment. As a result of its use the 6-inch gun under the most favorable conditions attained a rate of fire of 11 rounds per minute, and with the 7.5-inch gun, firing a 200-pound shot, a rate of fire of 8 aimed rounds per minute. The range was 1,100 yards, and all the shots struck within a meter square of the target. Such results have never been obtained with mechanisms entailing the use of the case system of obturation, and the author has no hesitation in pressing upon general notice the great advantages obtained by the quick-firing plastic-pad system of obturation. The system is equally applicable to guns up to the largest caliber, and a rate of fire of one round every fifteen seconds has been obtained with this form of mechanism with a 9.2-inch gun, which, starting with the gun loaded, means five rounds for the first minute of firing. Similar rates of fire from all heavy artillery on board ship would have such a moral effect as to influence the final issue of an engagement.

BREECH MECHANISM.

There are several features common to the breech mechanism of the 12-pounder 3-inch gun, 6-inch quick-firer, and the 9.2-inch and 12-inch breechloader, which are illustrated in figs. 10 to 20. The mechanism is of the Vickers single-movement type, whereby one motion of a hand lever or hand wheel performs the separate actions involved in the opening or in the closing of the breech. The one action locks or unlocks the breech lock, swings it in or out of the gun, and in opening and closing actuates the firing gear. In all cases the breechblock is of the Welin type, and is mounted upon, and free to turn on, a carrier pivoted at the right-hand side of the breech. The breech plug already described (fig. 7), because of its shortness, can be swung clear of the breech without longitudinal travel or curvature within the breech. The details of the mechanism for effecting the opening or closing of the breech differ slightly in each case, and even although it involves some little repetition, descriptions of each are given.

Breech mechanism for 12-pounder quick-firing gun.—In the breech plug for the 12-pounder 3-inch quick-firing gun, illustrated in fig. 10, there are 6 segments, and 4 are threaded; that is, two-thirds of the circumference is used for resisting strains.

The mechanism for actuating the breech plug A consists of a link B, one end of which is pivoted on a pin D, projecting from the rear end of the breech plug A; the other end is pivoted to a short crank C and pivoted on a bolt E, which may be quickly withdrawn when disassembling mechanism. Skew gear teeth are found partly round the periphery of the crank engaging with skew teeth formed partly round the axis of the hand lever G. This hand lever G lies close to the gun, and is so mounted that it may be quickly assembled or removed. The centers of the link B and crank C are arranged to form a locking point when the breech is closed.

The firing gear, which is arranged for percussion and electric firing and may be removed as one piece, is contained in a central hole formed through the stem J of the carrier F. It is retained in position by a cap M, with interrupted threads fitting into the rear face of the carrier F. The rear part of the cap M is fitted with a sleeve, this

sleeve having inclined planes formed on it, so that a partial rotation of the sleeve causes the striker R to be drawn back clear of the firing primer on the first movement of the hand lever to open the breech. The partial rotation of the sleeve is effected by a stud O projecting from it, and engaging with a cam groove N formed on the top of the hand lever G. When the sleeve has been turned to a sufficient extent, the hand lever swings clear of the stud O. The sleeve is retained in position by a sliding bolt acted on by the turning of the breech screw A. The striker R is cocked by hand for percussion firing, and a safety piece P, in the rear face of the breech screw, prevents the striker from being released until the breech is completely locked.

A powerful extractor Q is used, which extracts and ejects the empty cartridge case. This extractor is pivoted at the same side of the breech of the gun as the carrier F and is fork-shaped, the arms of the fork being approximately concentric with the cartridge case. The arms of the fork are provided with lips for ejecting the empty cartridge case. A third lip is formed in the bottom of the fork for unseating the cartridge case. This third lip is arranged, with respect to the lips on the arms of the fork, so that it comes into action first. A toe or third arm of the extractor Q is acted on by a cam surface (formed on the carrier F) during the last part of the swing-out when opening the breech.

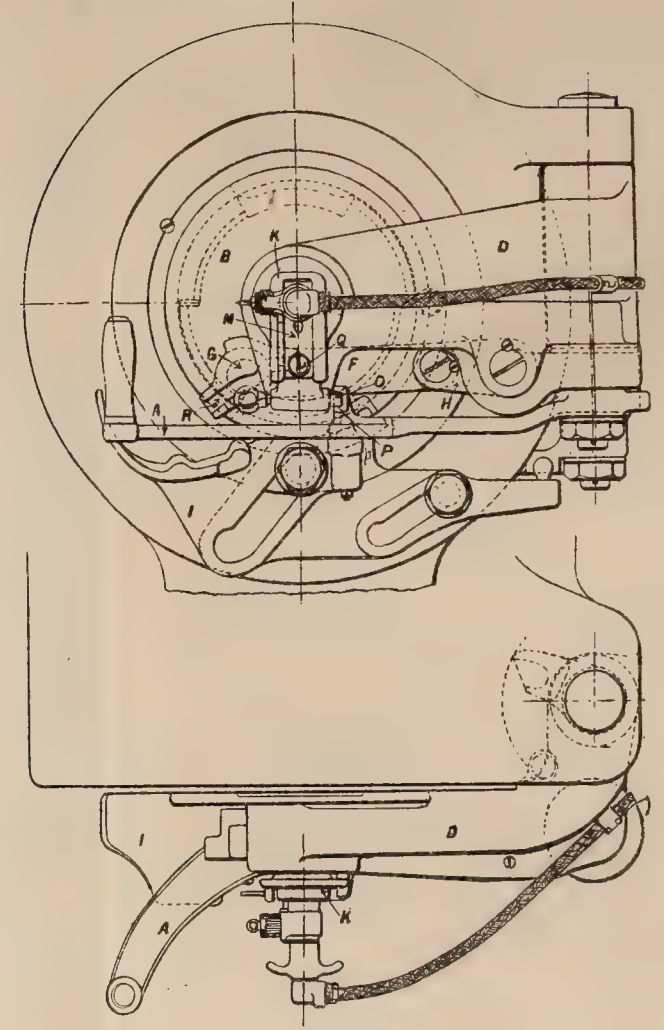
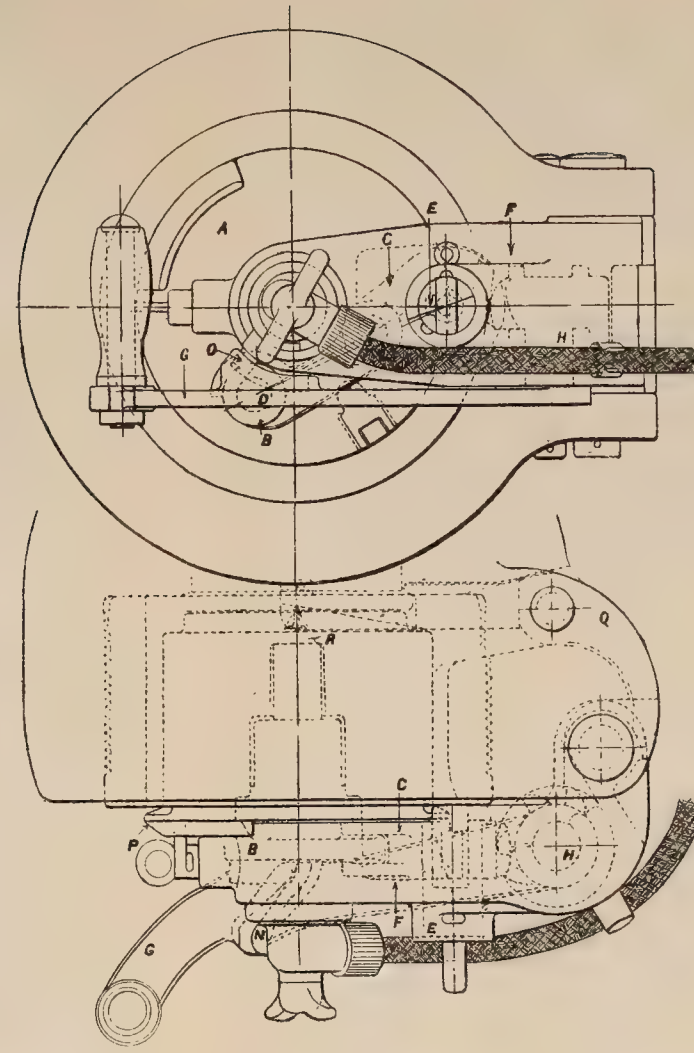
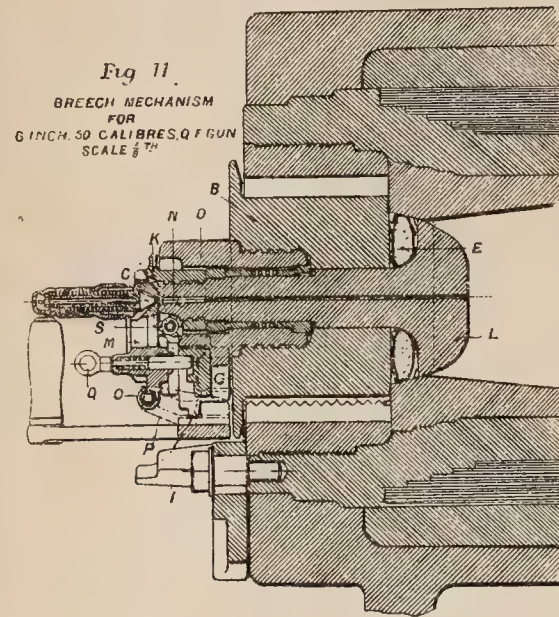
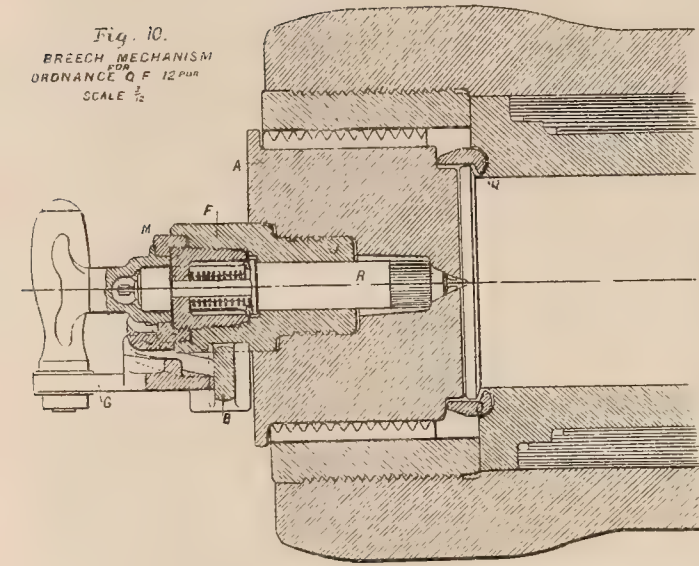
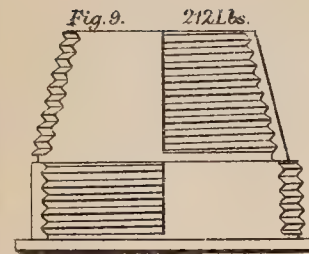
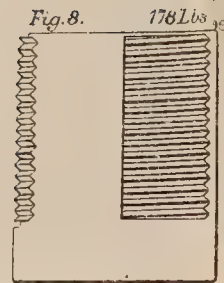
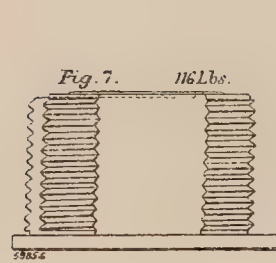
The action of the extractor Q is as follows: When the breech has been partly swung open, the cam surface on the carrier exerts a wedging action on the toe of the extractor, gradually unseating the cartridge case before the lips on the fork of the extractor Q come into action, and just immediately before the mechanism is completely swung out the toe of the extractor receives a sudden jerk, which causes the empty cartridge case to be completely ejected from the breech by means of the lips formed on the fork of the extractor. No small screws are employed, and no tool is required for use with this mechanism.

Breech mechanism for 6-inch quick-firing gun.—The breech plug for the 6-inch quick-firing gun, illustrated by fig. 11, and in perspective by figs. 16 and 17, is divided, so far as the threaded portion is concerned, into 6 segments, and 4 of these are threaded, so that in this case also two-thirds of the circumference is used for resisting the strains.

The link for actuating the breech plug is pivoted to a pig G, projecting from the breech plug B at one end and pivoted at the other end to a short crank H, which is mounted on the carrier D. Partly around the boss of this crank H are formed "skew gear" teeth, which gear with "skew" teeth formed around a sleeve keyed to the hand lever. A loading tray I is provided, which is automatically moved across the breech face of the gun and at the same time raised into the loading position while opening the breech (or lowered when closing it).

The firing gear is arranged for firing by electricity or percussion, and is directly operated by the hand lever A, so that the gun is absolutely safe against firing before the breech commences to open. For this purpose a nut K is fitted on the end of the obturating bolt L. In this nut a vertical slide M, which covers the end of the firing primer N, is worked by means of two spring bolts. One of these bolts O engages with a cam P on the hand lever A, the other, Q, in a groove R, in the link of the breech mechanism. An ejector S, actuated by the movement of a slide, is fitted in the nut. A spring-retaining catch is fitted in the obturator bolt, and prevents the tube from being jerked out, however violently the mechanism may be closed.

The motion is as follows: When the hand lever A of the breech mechanism is swung away from the gun, the cam P forces the slide M downward in the nut K. As the hand lever A continues to swing away from the gun, it eventually loses its connection with the spring bolt O of the slide M, and the downward movement of this slide is continued by the movement of the link F, which actuates the other spring bolt Q and keeps the slide M in the correct relative position until the breech is closed. When the slide M has been moved down far enough, it actuates the



12-POUNDER AND 6-INCH BREECH MECHANISMS.

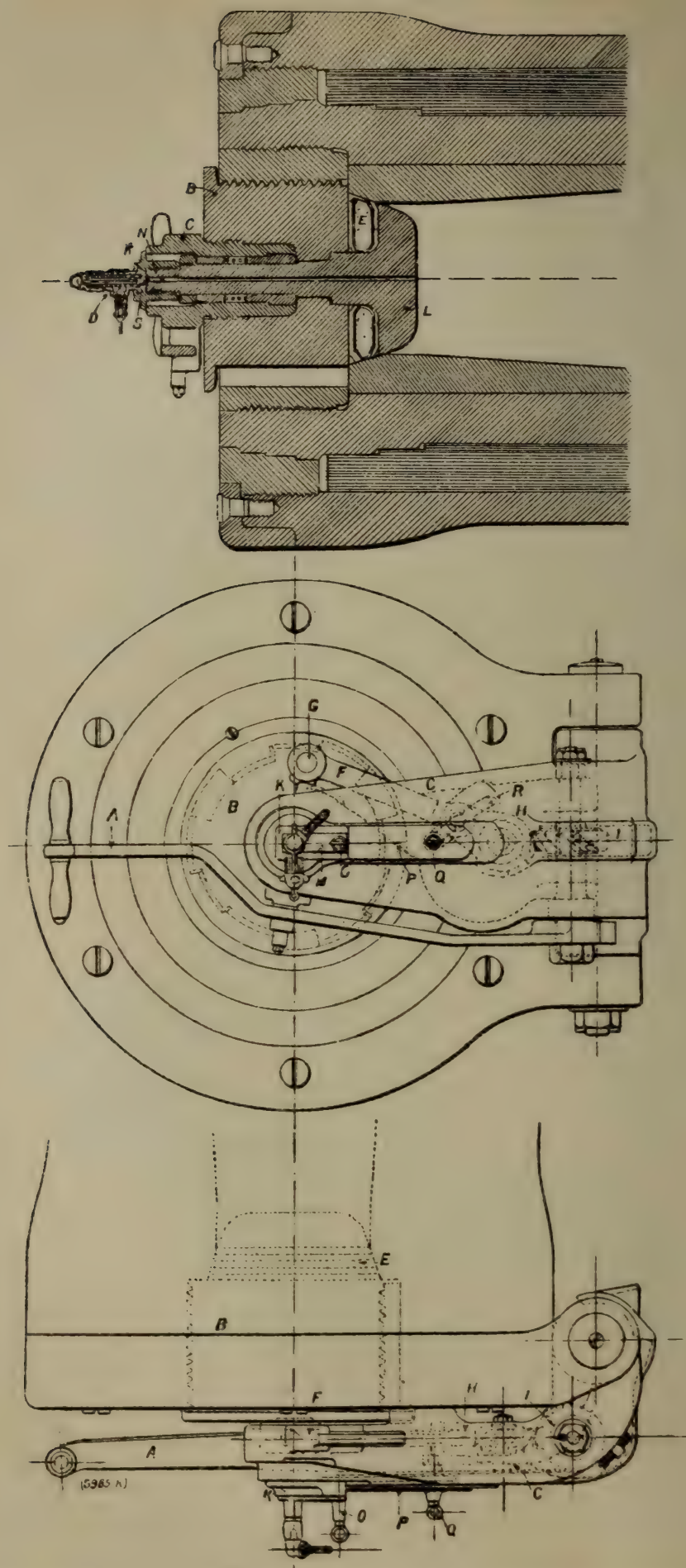


FIG. 12—BREECH MECHANISM (HAND LEVER) FOR 9.2-INCH B. L. GUN.
(SEE ALSO FIGS. 13-15.)

ejector S, thus jerking out the firing tube. On the first movement of the slide M downward, and before the breech has commenced to unlock, the firing needle C is partly drawn back by means of the toe with which it is provided, engaging with a quick incline on the rear of the firing gear nut. The spring bolts are arranged so that in the case of misfire the slide M may be pulled down by hand to a certain extent, sufficient to eject the tube without it being necessary to open the breech.

Breech mechanism for 9.2-inch breech-loading gun.—In the case of the 9.2-inch breech-loading gun, as shown in fig. 12, and in perspective on figs. 13 to 15, the threaded portion of the breech plug B is divided into 12 segmental portions of varying radii, and 9 of these are threaded, so that here three-quarters of the circumference is used for resisting the strains when firing.

As with the 6-inch gun, the mechanism for actuating the breech plug B consists of a link F, one end of which is pivoted on a pin G, projecting from the rear end of the breech plug B; the other end is pivoted to a short crank H, which is mounted on the breech-plug carrier C. Around the boss of a pinion I are found skew gear teeth. This pinion is keyed to the axis of the hand lever A, and is contained in a recess in the carrier C. The skew teeth so formed gear with skew teeth formed on the boss of the short crank H. The hand lever A lies close up to the gun, and the centers of the link F and crank H are arranged to form a locking point when the breech is closed.

The firing gear D is arranged for firing by electricity or percussion, and is operated so that the gun is absolutely safe before the breech commences to unlock. For this purpose a nut K is fitted on the end of the obturating bolt L; in this nut a horizontal slide M covers the end of the firing primer N, and is worked by means of a spring bolt O, which engages with a sliding bar P working in the face of the carrier C. The sliding bar P is also provided with a spring bolt Q, which engages with a cam R on the crank H. An ejector, actuated by the movement of the slide M, is fitted in the nut K. A spring-retaining catch is fitted in the obturating bolt L, and prevents the tube N from being jerked out, however violently the mechanism may be closed.

The action is as follows: When the hand lever A of the breech mechanism is swung on its pivot to open the breech, the crank H begins to move, and by means of the cam R it forces the slide M in the nut K away from the primer N. When the slide M has been moved away far enough, it actuates the ejector, thus jerking out the firing tube N. From this point the action is the same as in the corresponding action of the 6-inch gun mechanism previously described.

Breech mechanism for 12-inch breech-loading gun.—The breech mechanism for the 12-inch gun, which is shown in detail on figs. 18, 19, and 20, is so arranged that the whole of the breech action is operated and controlled by the rotation of a hand-wheel. By turning the handwheel A the breech plug B is first rotated and unlocked, and then swung out of the breech of the gun. The breech plug is mounted and free to turn on a carrier, L, pivoted at the right-hand side of the breech. The threaded portion of the breech plug is divided into 12 segmental portions of varying radii, and 9 of these are threaded, so that here, as in the 9.2-inch gun, three-quarters of the circumference is used for resisting the strains when firing. The obturator M is of an improved De Bange type. This improved obturator is also used in the 6-inch and 9.2-inch mechanisms.

The mechanism for actuating the breech plug B consists of a link C, one end of which is pivoted on a pin, D, projecting from the rear end of the breech plug B; the other end is pivoted to a short crank, E, which is mounted on the breech-plug carrier L. Around the boss of the crank E are formed "skew gear" teeth, engaging into similar teeth formed partly around the boss of a quadrant, F, which is mounted in the carrier L on a vertical pivot. This quadrant F has also formed partly round its periphery ordinary spur teeth, which engage with similar teeth on a second quadrant, G, fixed on the hinge bolt H of the carrier L. The hinge bolt H, together with

its quadrant G, is revolved by means of a worm, I, and a worm wheel, K, which are in turn actuated by the handwheel A, mounted at the breech of the gun. To open the breech the handwheel A is rotated, and thus, by means of the wormwheel K, the quadrant G causes the quadrant F and crank E to turn, thus rotating the breech plug B until it becomes unlocked.

By continued turning of the handwheel A, the carrier L, with the breech plug B, is swung out clear of the breech of the gun. The opposite action takes place on closing the breech.

As in the case of the 9.2-inch breechloader and 6-inch quick firer, the gun is arranged to be fired by electric or percussion tubes. For this purpose a nut, N, is fitted on the end of the obturating bolt, O. In this nut a horizontal slide, P, which covers the end of the firing primer Q, is worked by means of a spring bolt, R, which engages with a sliding bar, S, working in the face of the carrier L. The sliding bar S is also provided with a spring bolt, T, which engages with a cam, U, on the crank E of the toggle joint. An ejector, actuated by the movement of the slide P, is fitted in the nut N. A spring-retaining catch is fitted in the obturating bolt O, and prevents the tube from being jerked out, however violently the mechanism may be closed.

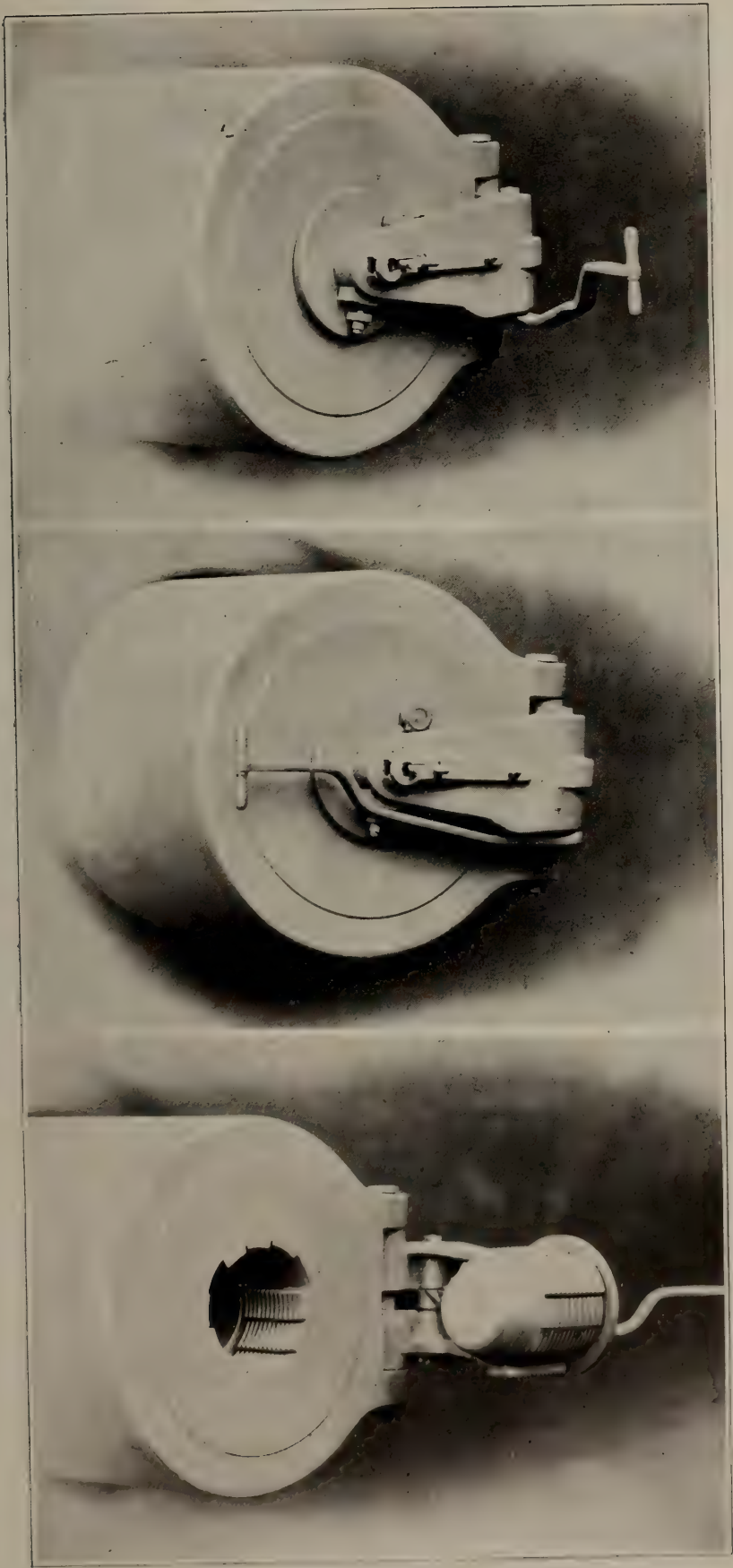
The action is similar to that in the 9.2-inch gun previously described.

Hydraulic v. steam, air, and electric motive power.—The mounting for the gun is as important as the gun itself or as its breech mechanism, because upon the efficiency of the mounting the rate of fire depends. The structure, while extremely mobile, must be sufficiently strong to transmit to the ship the strains that result from the enormous energies developed when the gun is fired. The rapidity and accuracy of aimed fire are controlled to a large extent by machinery—the elevating and training gear, the means of supplying the gun with projectiles and powder, the hoist, the rammers, etc. The motive power by which this machinery is operated considerably influences the general efficiency of the mounting, and on this point there is much difference of opinion. This is one of the several questions where the varied experience of the mechanical engineer can assist the ordnance designer. Varying circumstances affect the general rules, and necessitate special divergence from any principle laid down; but the author is much inclined in favor of hydraulic power for the general operation of the mounting, in preference to electricity, compressed air, or steam.

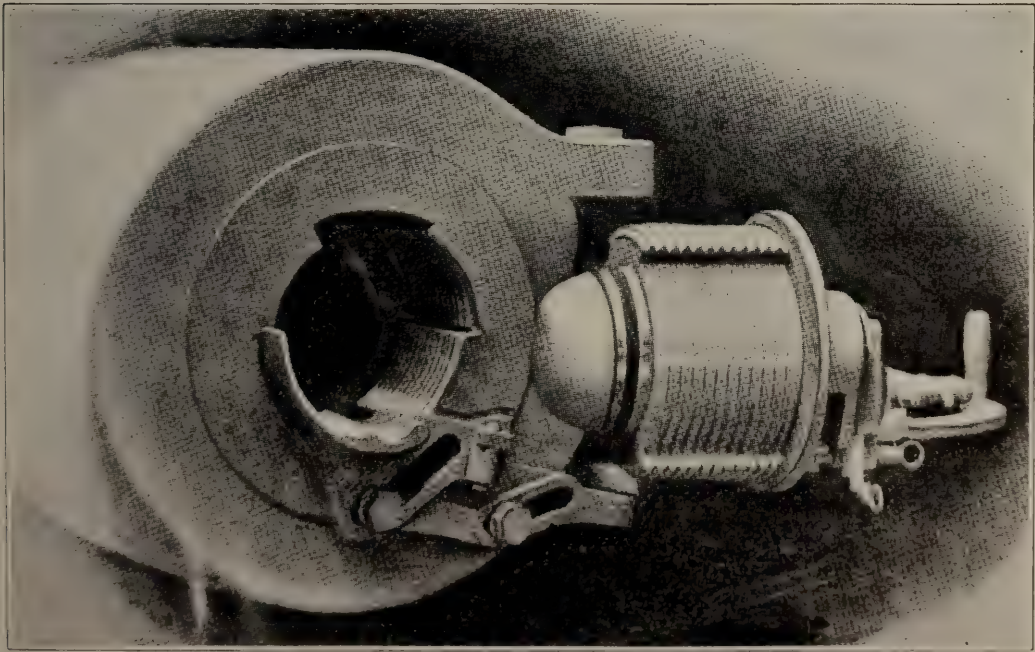
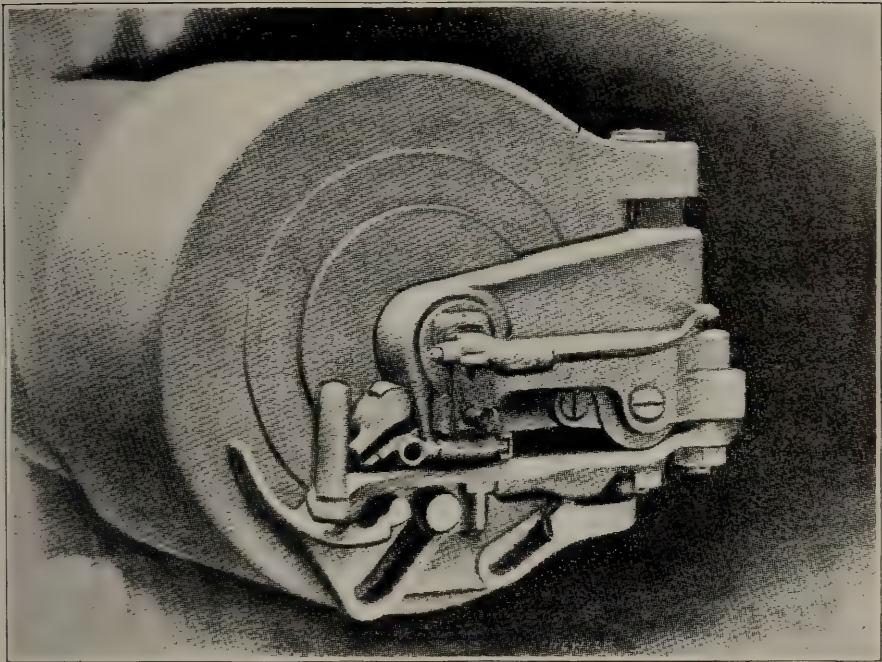
Steam power.—For sea service it is very important to avoid any system which will cause the lower deck and compartments in the ship to become heated, especially as there is usually great difficulty in ventilating such places to make them habitable. Steam engines with their pipe leads, valves, etc., which must radiate much heat, are impracticable from this cause alone; but in addition to this disadvantage they are next to impossible inside a turret, owing to the danger of the gunners being scalded in the possible contingency of joints being damaged or pipes broken in action. Again, in consequence of the intermittent nature of the work done, there is likelihood of failure, owing to the steam condensing in the cylinders and steam leads. This might be overcome by a properly designed system of draining, but this would add complications.

Compressed-air power.—Compressed air has one great advantage in comparison with steam—no return pipe system is required, as all machines may exhaust into the atmosphere, and by so doing would materially assist in the ventilation of the turret. The noise, however, made by the free exhaust is very objectionable. Compressed air, to be economical, must be worked at a very high pressure, and a damaged pipe might therefore cause an explosion with serious results. Air-compressing engines are usually run at a high speed, and necessitate the employment of gear trains—a condition extravagant and noisy.

Electric power.—Electricity, when compared with steam and air, has many advantages; no pipes are required, the conductors are extremely light as compared with



FIGS. 13, 14, 15.—9.2-INCH BREECH MECHANISM.



FIGS. 16, 17.—BREECH MECHANISM FOR 6-INCH QUICK-FIRING GUN.

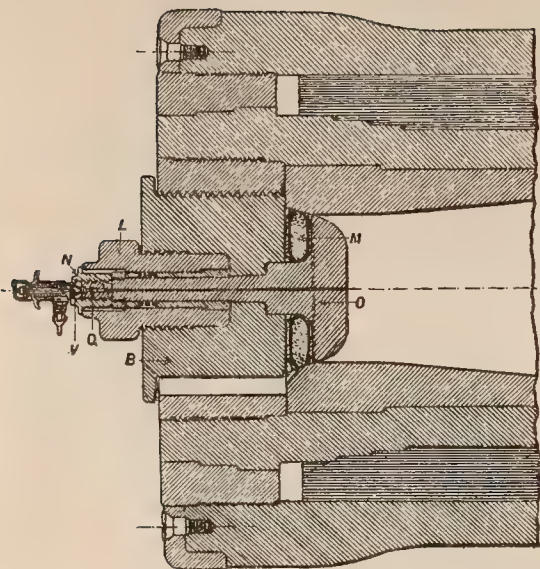


FIG. 18.

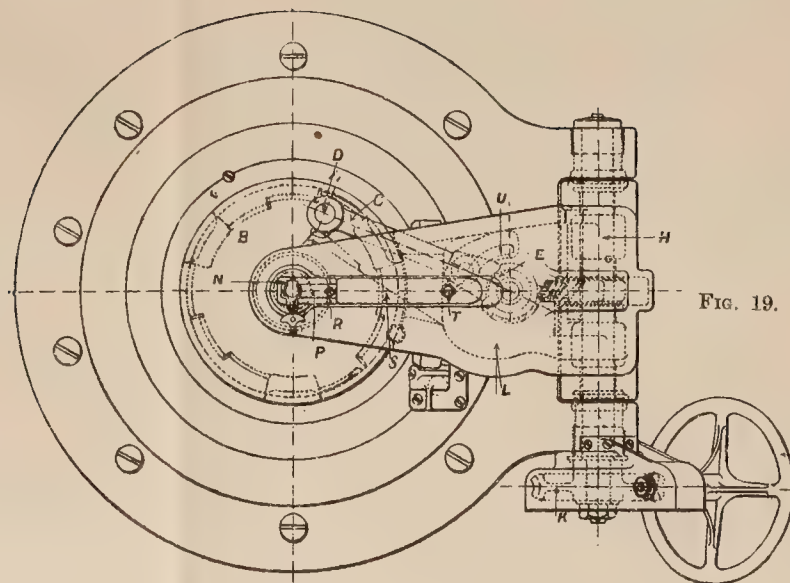


FIG. 19.

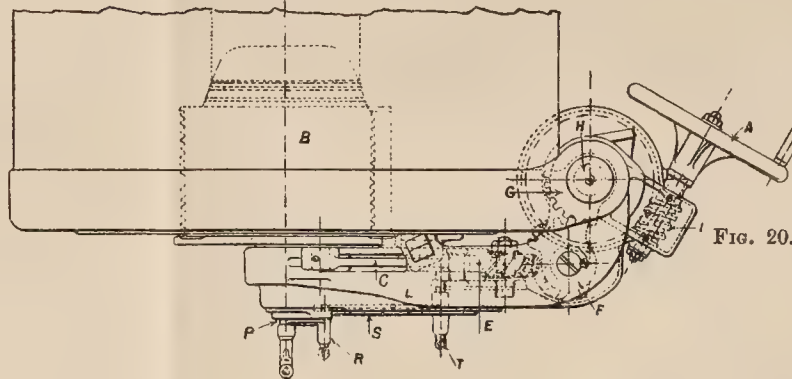


FIG. 20.

BREECH MECHANISM FOR 12-INCH B. L. GUN.

the pipes which they would displace, and they can be led anywhere. On the other hand, there are a number of serious disadvantages involved. All electric motors of reasonable weight and size for the purpose must run at a very high speed, necessitating heavy gear trains, which involve much loss of power and a great deal of noise. Difficulty, too, is frequently experienced in discovering the cause of failure which occasionally occurs either in the motor, controller, or conductors. Special safety cut-outs are required to prevent motors from overheating. It is also practically impossible to utilize electricity for running heavy guns back to the firing position after recoil. In training and elevating by electricity, great difficulty is always experienced in getting dead slow movements to enable the gun to be perfectly sighted on the target. Many devices have been introduced to overcome this drawback, but none have proved quite satisfactory; an electric motor can scarcely be started at slow speed. Again, it is generally stated as one of the advantages of electric over hydraulic power that if a wire breaks it is more easily repaired. This, however, is not the experience of the author, as it has often proved most difficult to detect quickly a short or broken circuit. With hydraulic power the escape of water is certain and is easily discovered; and, since the introduction of flexible piping, a broken pipe is quickly repaired by replacing the whole piece between the two stopcocks.

Hydraulic power.—Hydraulic power has practically none of the disadvantages enumerated for the other systems of power described. Pipes can be laid anywhere, they give out no heat, if they are damaged no explosion takes place, and the damage can easily be discovered and quickly repaired. Hydraulic machines can in most cases be applied direct for elevating, running out and in, lifting ammunition, and for hauling projectiles, etc., in the shell rooms and other parts of the ship. They work practically in silence. The vertical and horizontal running of the gun is under perfect control, the dead slow movement required being obtained with the greatest facility and precision.

For sea service, the source of the hydraulic power on board ship is usually a pumping engine, so designed as to obviate the necessity for an accumulator. One engine is fitted for each turret, and placed in a compartment below the armor deck, the arrangement of valves being such that either or both can work any or both of the mountings. These engines are of the compound tandem type, each with four cylinders and two pumps placed in line. They are provided with speed and pressure governors to admit of variations in the speed from 3 to 110 revolutions per minute, with pressures within 1,000 pounds and 1,100 pounds per square inch. The pumps are single-acting for suction work and double-acting for delivery. Large tanks built into the ship are provided for storing fresh water, in which there is a slight admixture of soft soap and oil for the lubricating of internal surfaces. Salt water may be used in an emergency, but this is not commendable. Duplicate sets of piping are provided throughout the ship. To keep down weight, these are usually made of manganese bronze, a material of about twice the strength of the copper formerly adopted.

GUN MOUNTINGS.

After due consideration has been given to strength and adaptability, the principal point in the general arrangement of gun mountings, as in the mechanism of the gun itself, is to attain the highest possible aimed rate of fire. This indeed is the dominant consideration in the designing of all gun mountings, and the attainment of this result is established by reference to the illustration (fig. 23) of the mounting for two 12-inch breech-loading guns installed in several British first-class battleships. The distinctive feature of the arrangement admits of the gun being loaded at any angle of elevation, and the loading is quite independent of the laying of the gun. In earlier types it was necessary after the gun was fired to elevate it again to a fixed angle in order to reload. This not only threw the weapon off the line of sight, but

took quite an appreciable time to perform, reducing the possible rate of aimed fire in a given time.

In British ships the 12-inch guns are invariably mounted in pairs, and the arrangement illustrated by fig. 21 admits of four rounds being fired from each barbette, or at the rate of 149.241 foot-tons per minute. With guns of this caliber it would seem desirable to always mount them in pairs, so that if the range is not found quite correct with the first projectile from the one gun, there is immediate opportunity of rectifying the error discovered, and thus the gun layer will seldom fail to hit with the second shot. It is the case over again of the ordinary barreled gun—if you miss with one barrel you always have a second. In the case of the battleship, if you hit with the first gun the chance is you will also hit with the second.

Vickers's barbette mounting for two 12-inch breech-loading guns for British service.—In the barbette mounting for two 12-inch breech-loading guns of the British type, illustrated by fig. 21, the guns are mounted on a turntable, carried on a live roller ring, and are protected by an armored shield secured to the upper surface of the turntable. The following is a detailed description:

The turntable A is built up of steel plates and angles, and is provided with suitable machined surfaces for the attachment of the brackets supporting the gun mountings and for the upper roller path *a* secured to its lower face. The lower roller path *b* is fixed to a structure separate from and within the barbette wall, and thereby will not be affected by any distortion of the latter.

The shell chamber C is attached to the under side of the turntable, and revolves with it.

The trunk D is attached to the floor of the shell chamber, and revolves with it and the turntable.

The rollers B are provided with flanges at both ends to take the horizontal thrust, and are bound together by a ring to which the roller axles are secured.

The training rack E is attached to the turntable, and gears with the training pinions *e*, which are actuated from below. The turntable is arranged to be rotated either by hydraulic or hand power, and provision is made so that only one form of power can be in operation at the same time. For training by hydraulic power two 3-cylinder hydraulic engines F are provided, which may act either in conjunction or separately; they are situated in a compartment immediately below the shell chamber, and are controlled from the sighting stations.

The handles G for hand working are situated in the same compartment as the hydraulic engines, and are suitably connected by gearing to the training shafts *f*. An automatic brake, *d*, is provided, which will always be in action when the hand or hydraulic power is not actually at work, and the locking bolt *z* is arranged to secure the turntable when not in use.

The guns are mounted in cradles W, which slide during recoil upon slide frames I₁, built up of steel plates and angles. The slide frames are supported by trunnions *g* in bearings on suitable brackets attached to the upper part of the turntable.

The recoil presses H are fixed to the slide frames, two to each gun. These presses are provided with pistons and rods, the latter being attached to the cradle. During recoil the liquid in the press is forced through an opening of varying area to give an approximate constant pressure throughout the period of recoil. The gun may be run out or in either by hydraulic or hand power. For running out or in by hydraulic power two presses are provided, one for each operation. These are fixed inside the slide frame under the gun, and have a single ram working between them, which is secured to a sleeve on the under side of the gun cradle, and moves with it. The operating valves are situated on the gun platform.

For hand power run "out" and "in" hand pumps J are provided in the chamber below the turntable, and are suitably connected up to the "run in and out cylinders." These pumps are also used for hand "elevating," connections being likewise provided to the elevating presses LL.

For elevating by hydraulic power a bracket, K, attached to the under side of the slide frame in front is connected by means of two links, k , to the ram of a press, L L, which is attached to the floor of the turntable. This press is operated either from the sighting platform or the gun platform. The hydraulic supply is conveyed to the revolving turntable by means of the swivel pipes PP.

Automatic sighting gear is provided on the gun mounting, and is arranged in duplicate for each gun.

The projectiles and explosive charges are conveyed from the shell rooms and magazine to the shell chamber in cages, which travel along guides in the trunk. The projectiles are transferred from the overhead traveler y in the shell room onto two bogies Y at the base of the trunk. These bogies are provided with gear for running them round relative to the ship or to the revolving trunk, and have bolts which support the projectile, which, when withdrawn, allow the projectiles to roll down onto a receiving tray in the cage. The cages in the trunk travel vertically until they reach the chamber below the turntable, whereupon the trays carrying the projectiles are automatically tilted so that the projectiles roll onto receiving trays n_1 . These trays are themselves tilted on a horizontal axis until they come in line with the inclined trays n_2 leading to the ammunition cages, which carry the ammunition from the shell chamber to the gun breeches.

The rails SS leading from the shell chamber to the gun platform have their upper parts curved concentric with the trunnions, so that the projectile carried on the cage is always radial in the upper part of its course, and may be brought in line with the bore of the gun whatever be its elevation.

The powder charges are raised from the magazine, which is situated immediately above the shell room, to the shell chamber in cages Q, which travel up guides in the trunk in a similar manner to the shell cages. The charges are then lifted out and placed in the main ammunition hoists R_1 leading to the gun breeches.

A loading tray, T, arranged to work on a horizontal axis, is kept by a spring in its lower position out of the way of the gun when it recoils. This tray is raised by a cam on the ammunition cage, and swung around its horizontal axis into the bore of the gun after the breech has been opened, and in this position effectively protects the threads of the breech screw during the passage of the projectile and powder charges into the gun. At the rear of this loading tray a chain rammer, V, is provided, worked by means of a hydraulic motor, the arrangement being that the rammer is always in line with the longitudinal axis of the gun for loading at any angle of elevation.

The motor for working the rammer is attached to the arm I_2 , which carries the loading tray, and connected by bevel gear v to the rammer.

Should the motor or other part of the gear fail, a clear space may be provided for hand loading from a bogie, R_2 , at the rear of the gun by lowering the gearing and its connection by means of a screw.

All the ammunition cages are worked by hydraulic cranes. The main ammunition cages abut against fixed stops on the rearward extension of the slide frame, so that the projectile is brought exactly in line with the bore of the gun, thus insuring that the gun may be loaded at any angle of elevation, whether in motion or at rest.

The mounting is inclosed by a shield, M, securely attached to the upper floor of the turntable by suitable plates and angles. The front and sides are sloping. The rear part is extended to provide space for the gun's crew, and also serves to balance the mounting. The opening between the shield and the barbette wall is made watertight by means of a flexible leather apron, m , which may be adjusted by means of screws.

There are two sighting hoods and one lookout hood at the rear.

Foreign service Vickers mounting for two 12-inch breech-loading guns.—The diagram (fig. 22) differs in one important respect from the arrangement for the British ships just described. Each charge for the main hoist is transferred direct to the gun hoist,

the elevator trunk being splayed outward at the top, so that the projectiles are brought up exactly in line with the axis of each gun. In this arrangement nine projectiles are always kept in motion in various positions, and the guns constantly kept supplied with ammunition, so that they may be virtually considered quick firers. It is only necessary to describe in detail that part of the ammunition hoist which differs from the arrangement in the mounting shown in fig. 21.

The cages N in the conical trunk travel upward on slightly inclined rails *m*, until they reach the chamber below the turntable, and the projectiles which they carry are now in line with the guns. The cages are provided with trays carrying the projectiles, which are automatically tilted when the cage has ascended, so that the projectiles slide off into fixed receiving trays *p* in the shell chamber, where they remain until the ammunition cages R, which carry the ammunition from the shell chamber to the gun breeches, have descended and automatically set free the stops which retained them in position, permitting the projectiles to slide into the ammunition cages.

9.2-inch gun, barbette mounting.—In fig. 23 there is illustrated the equipment for a medium-caliber gun specially suited for armored cruisers, and which, for its size, has attained the greatest rate of fire of any gun at present mounted in His Majesty's navy. This is a 9.2-inch equipment, which is to all practical purposes similar to the guns now under manufacture, with their mountings, for the Turkish battleship *Messudijeh*. A general description of the mounting is given, as it is of special construction, and is capable of attaining a rate of fire of five rounds per minute. The mounting itself would not produce this extraordinary rate of fire; it is due to the construction of the breech mechanism illustrated by fig. 12, in combination with the general arrangement of the mounting. The breech mechanism can be operated, either in opening or closing, in about two seconds, so that very little time is wasted in performing the whole operation. No hydraulic or other mechanical device is needed, as the arrangement of levers gives ample power when worked by hand. The following is a detailed description of the mounting as illustrated by fig. 23.

The turntable A is built up of steel plates and angles. The upper roller path *a* is riveted to its under face and machined up true in position. The lower roller path *b* is secured to a machined surface on the floor of the barbette. The rollers B, B are provided with flanges at both ends to take the horizontal thrust, and are bound together by a ring of plate steel, to which the roller axles are attached.

The turntable is arranged to be rotated either by hydraulic or hand power, the former by means of a 3-cylinder hydraulic motor F, gearing with a rack E, attached to the lower roller path, and the latter by means of handles D situated on the gun platform. The shaft carrying the pinion which gears with the training rack is arranged vertically, and carries two spur wheels *f*₁, *f*₂ loosely thereon, to one of which is geared a pinion on the shaft of the hydraulic motor, and to the other is geared a pinion connected to the hand gear. The wheels are connected to the shaft by means of a clutch *f*₃, so arranged that only one can be in operation at the same time.

A hand brake is provided for securing the turntable when changing from hydraulic to hand power, and vice versa. The hydraulic motor is controlled from the sighting station by means of the hand wheel N.

The gun is mounted on a slide frame S built up of steel plates and angles, provided with bearings upon which the gun slides during recoil. The slide frame is supported by trunnions on bearings *g*, in suitable brackets G secured to the upper parts of the turntable.

The recoil presses H, two in number, are fixed to the slide frame. These presses are provided with pistons and rods *h*, the latter being attached to the lug band C secured to the gun, and arranged to slide on a prolongation of the slide frame. The presses have an orifice of varying area to allow the liquid in the cylinder to pass from one end to the other during recoil at an approximately constant pressure.

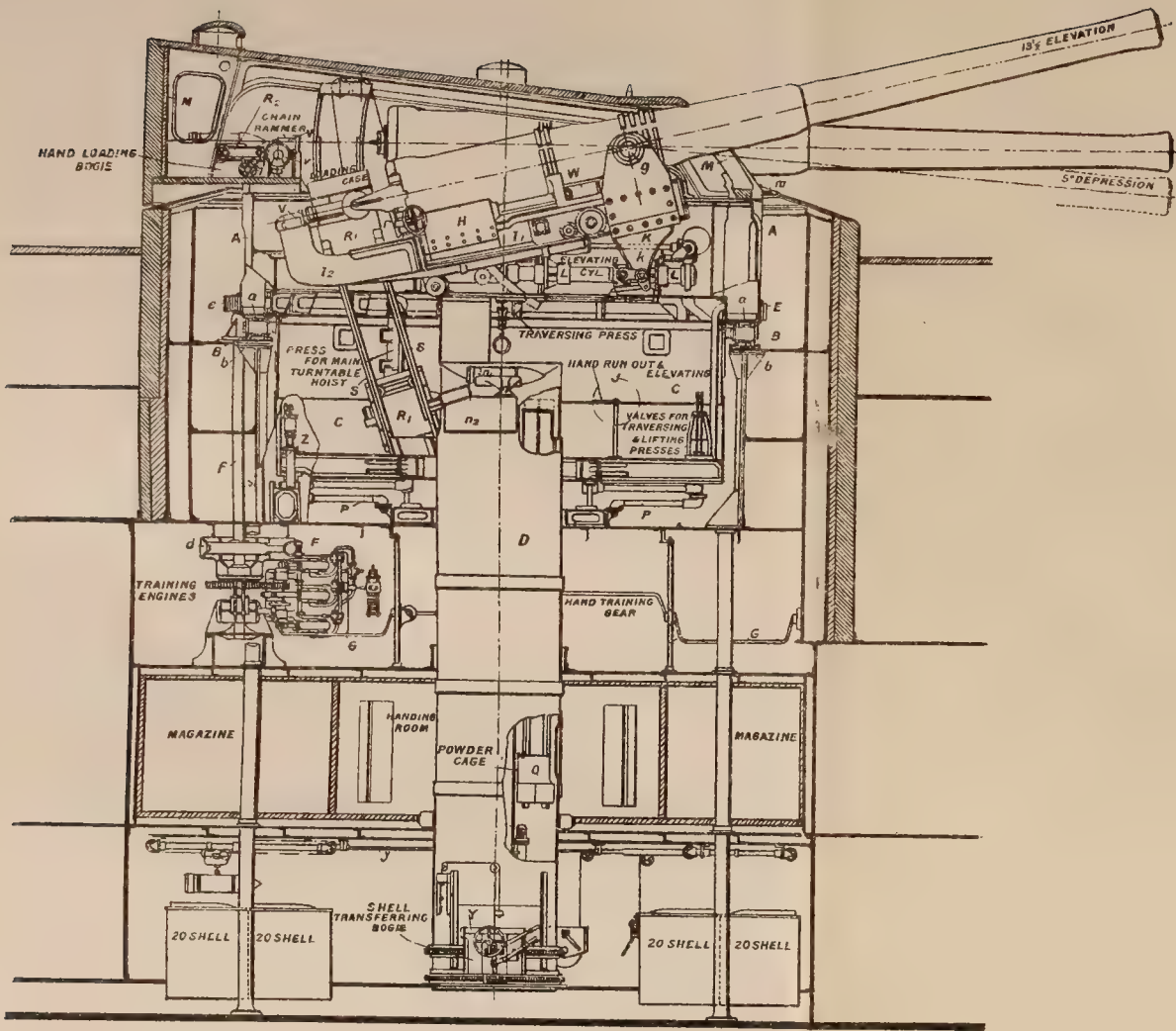


FIG. 21

BARBETTE MOUNTING FOR TWO 12-INCH GUNS.

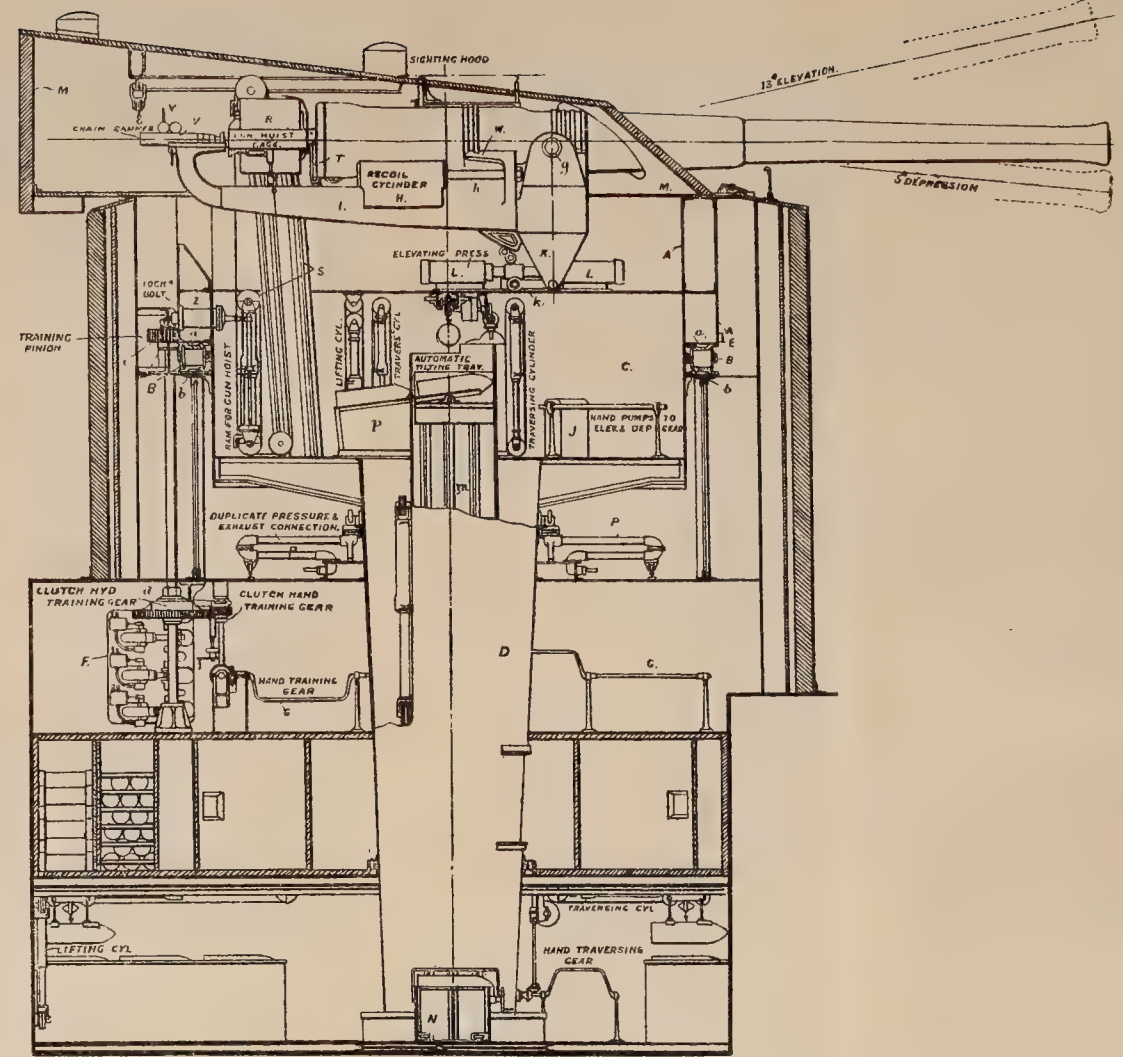


FIG. 22.



The gun is provided with two rows of recuperator springs placed inside the slide frame, which hold the gun in the firing position, and are of sufficient power to return the gun after fire to the firing position at all angles of elevation. Suitable arrangements are made in the recoil cylinders to prevent the shock when returning to the firing position with the gun horizontal or depressed.

The gun is arranged to be elevated either by hand or hydraulic power. The elevating press *P* is secured to the turntable below the gun, and is connected by links *p*, to the bracket *R* on the under side of the slide frame. The press is controlled by a lever *n* from the sighting station. Handwheels are provided at the sighting station for elevating by hand *I*₁, and also from a secondary position in the gun platform *I*₂. They are connected by worm and other gearing to the elevating arcs *K* attached to the under side of the slide frame, two pinions *q* on the worm-wheel shaft being geared thereto. An automatic arrangement is provided for disconnecting the hand gear when the hydraulic power is employed.

Automatic sights *s s* are provided on the gun mounting, and an indicator situated at the sighting station shows the position of the mounting relative to ship when training.

An arm *Q* attached to the gun slide supports the loading tray *L*₂, onto which the projectiles are placed for loading. The mechanism of the loading apparatus is such that the projectile always remains parallel with the axis of the gun when the tray with shell is swung into the breech of the gun.

From the under floor of the turntable a trunk *T*₁ is arranged to extend down into the interior of the ship to the level of the ammunition chambers. It is rectangular in section, and the interior is used as a passageway and hand-up. The guide rails *r r* for the ammunition hoists are fixed to the outside. A platform *T*₂ is attached to the under side of the turntable, and revolves with it, from which a ladder *L*₁ extends to the gun platform; it may be used for carrying the spare ammunition for handing up.

The projectiles are delivered on one side of the gun and the powder charges at the other, one projectile and two half charges being conveyed at a time. The shells slide down an inclined trough *T*₃ from the cage to a convenient position at the rear of the gun, from whence they are lifted into the loading tray. The powder charges are carried round by hand to the rear of the gun. Both hoists are worked by hydraulic presses.

The projectiles and powder charges in case of necessity can be raised by hand through the ladder ways to the gun platform.

The mounting is inclosed by a shield *M* securely attached to the upper floor of the turntable by plates and angles. It is provided with a sighting hood, and is fitted with a leather apron *m*, with screws and brackets for making it water-tight with the barbette.

Krupp barbette mounting for 24-centimeter (9.45-inch) gun.—In dealing with the mountings of heavy ordnance it may not be amiss to refer to a type of 24-centimeter gun designed by Messrs. Krupp, of Essen, of which a general diagram is given on fig. 24. The main operations of this mounting are performed electrically, but the mechanism can be quickly disconnected to enable the gun to be worked by hand. The recoil of the gun is overcome by a hydro-pneumatic device, and the rammer is worked by hydraulic power. Messrs. Krupp thus fit three power systems for performing different operations in connection with the working of one mounting. The breech mechanism of the gun is of Messrs. Krupp's usual wedge type, and is worked by hand. It is claimed for the mounting that it will fire one round every twenty seconds—that is, starting with the gun loaded, four rounds in the first minute and then one round every twenty seconds thereafter. The turntable itself revolves on a ball race, and the mounting generally is well protected by the highest quality of armor. The maximum rate of fire obtained from the Vickers 9.2-inch mountings was five

rounds in one minute, starting with the gun loaded, and, as already pointed out, this extraordinary rate of fire from such a heavy weapon has been accomplished by the combination of the general arrangement of the mounting with the mechanism of the gun, and the abolition altogether of the metallic-cartridge case. The following is a detailed description of the Krupp barbette mounting for 24-centimeter breech-loading gun, as illustrated by fig. 24.

The mounting consists essentially of the following parts: The turntable A, for loading the ammunition hoist; the rotating trunk B, carrying the gun-platform C and carriage D; training and elevating gear E; ammunition-hoisting gear F and rammer G; gun shield H.

The turntable, which is rotated by hand power on a live roller path, is built up of plates and angles, and carries twenty-four projectile holders K, arranged in a circle and secured by clips. The trunk, which rotates independently of the turntable, is centered at its lower end by a pivot L, which rotates in a fixed bearing. Rails attached to the trunk guide the cap M while it is being elevated. The upper part of the trunk is circular, and is strengthened by cross girders N and angles to carry the gun platform and carriage. A ball path fixed to the underside of the platform rests on a racer P, fixed to the deck and provided with steel balls, which thus support the trunk and gun mounting, while clips fitting underneath an internal flange on the racer prevent the ball path unseating when firing.

The traversing rack Q, which gears with the traversing pinion, is formed on the outside of the racer. Traversing may be effected either by electric or hand power; the crank handles R for the latter are placed in a pit immediately below the platform, and connected to the traversing shaft by a chain drive and double-speed gear. Access to this pit is obtained through hatchways in the platform. When the maximum traverse has been reached in either direction, the platform comes in contact with a spring buffer, and the motor is automatically thrown out of gear. A powerful electro-magnetic brake is also provided.

The elevating arcs attached to the cradle crosshead are provided with graduated sectors S, and gear with the elevating pinion, actuated either by an electric motor T or by hand power, and an indicator U, actuated by the sight, registers the angle of elevation required. The movement of the arcs is limited by stops, the motor being automatically thrown out of gear when maximum elevation or depression is reached, and an arrangement is provided for locking the gun at the elevation necessary for loading.

The controlling levers for the traversing and elevating motors are actuated from the sighting station, and the change from electric to hand power is accomplished in a few seconds by means of clutches.

The gun is mounted in a cast-steel cradle V, and the cradle supported in the carriage by trunnions, so that during recoil the gun slides in the cradle. The two recoil cylinders are formed on a cross head fixed to the cradle, and the running-out cylinder placed between them; each recoil cylinder is provided with a piston and rod, the latter attached to the horn on the gun. During recoil the liquid in these cylinders is forced through an opening of varying area, to give an approximately uniform pressure throughout the period of recoil. Compressed air in the running-out cylinder, being further compressed during recoil, serves for running out the gun. The air cylinder is provided with regulating valve and manometer gauge.

A range finder and automatic sight are fitted to the mounting.

One projectile and one charge are elevated simultaneously from the turntable to ramming position, the inclination of the hoist tray W being controlled by the guide rails fixed on the trunk. The tray is pivoted in the hoist cage, and has two divisions—the upper, which is movable for the charge, and the lower, which is fixed for the projectile. The charge is placed in a swing carrier and secured by a clip, which is automatically pushed back on bringing the carrier into position for loading the

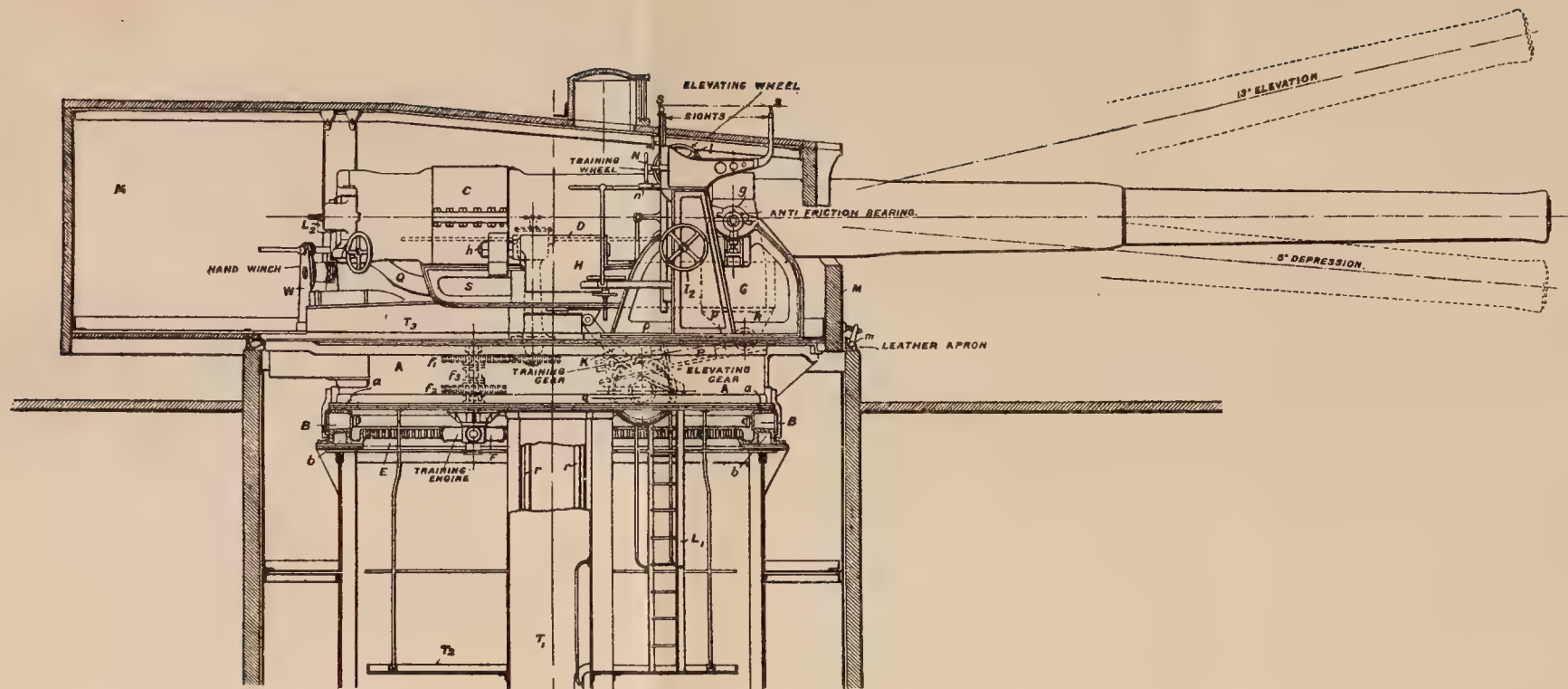


FIG. 23—BARBETTE MOUNTING FOR 9.2-INCH B. L. GUN.



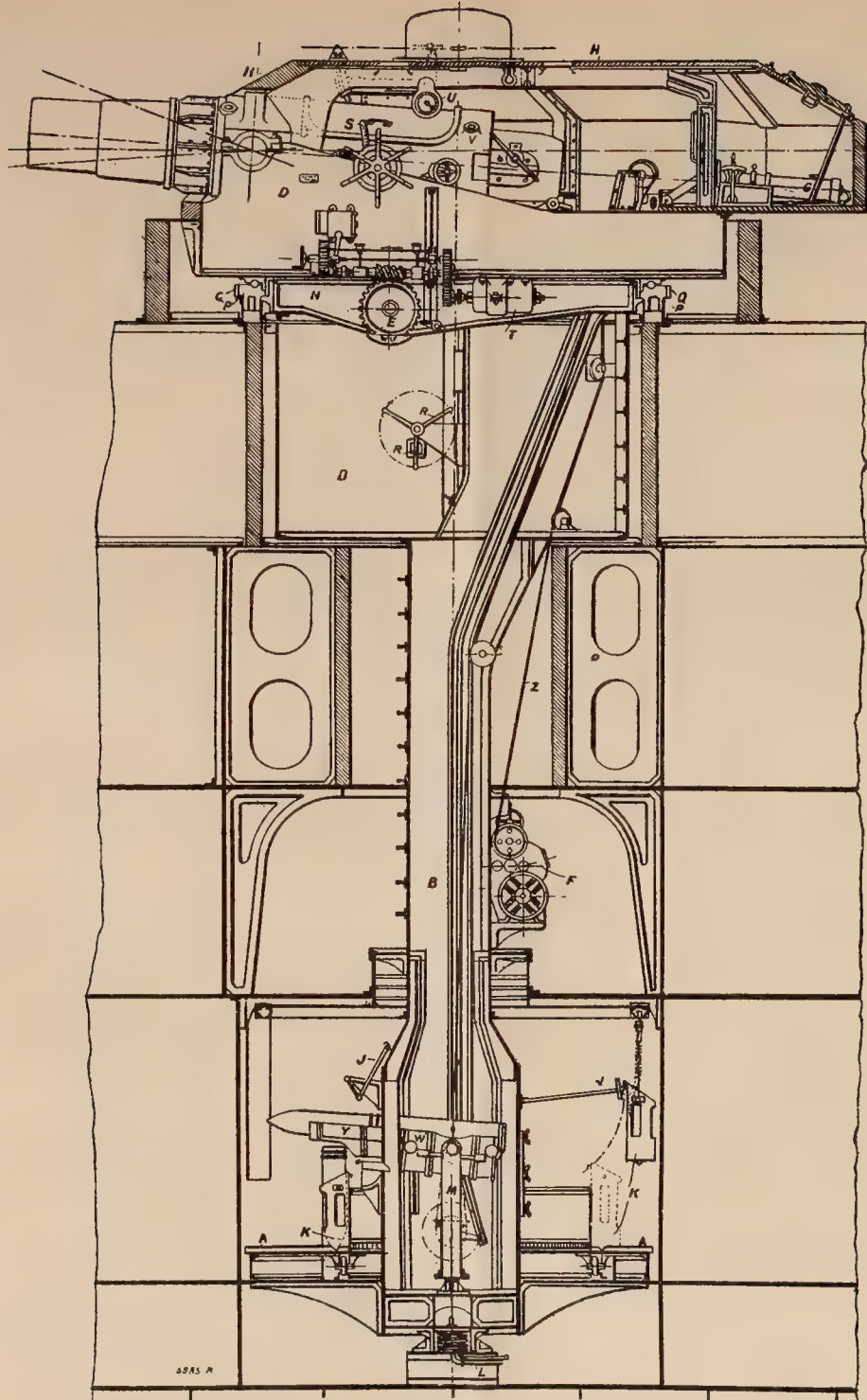


FIG. 24—BARBETTE MOUNTING FOR 24-CM. GUN (KRUPP TYPE).

tray. The projectile in its holder is lifted up by means of a hook and lever into a position which allows it to be pushed into a carrier Y, fixed on the trunk, where it is secured by a spring catch, which on withdrawal allows the projectile to be pushed into the lower division of the tray. The cage is elevated by a rope Z, coiling on a drum actuated by the electric motor F. The motor is slowly started by hand, and the cage on rising automatically throws in the full current; on reaching the gun platform the tray cuts out the current, and is then brought to rest in position for ramming the projectile by a stop, the cage being held in this position by an automatic clutch. At the lower part of the trunk an arrangement is provided which indicates the position of the tray in the hoist, together with a bell, speaking tube, and telegraph for communicating with the gun platform.

The rammer is arranged to be in line with the gun's axis, and consists of a series of telescopic rams actuated by compressed air or by hand. After the shell is rammed a lever is withdrawn, which allows the charge to fall into the position previously occupied by the projectile.

When the elevating tray is loaded, a slight rotation of the turntable brings another projectile opposite the carrier Y, in which the projectile may be placed in readiness for the descent of the tray, and at the same time an empty holder is brought opposite a loading table, where it receives a projectile, and is replaced in position on the turntable by an overhead trolley and swing link X.

An arrangement of a trolley running on rails concentric with the trunk, combined with a swing link J, is provided for loading direct from the depots.

The mounting is inclosed in a shield securely attached to the gun platform by stretchers and angles, the front sloping and the rear extending over the barbette to provide space for ramming. The shield extends downward to the top of the barbette well and is provided with a sighting hood and manhole at the rear.

Twin quick-firing guns in barbette mountings.—In the case of cruisers, where saving of weight is of great importance, it is desirable to mount in the fore and after barbettes quick-firing guns singly or in pairs. Where two are to be mounted on forecastle and poop, it is important to have them on separate mountings, not too close together, as otherwise one gun may interfere with the other while loading. When thus in pairs the processes of elevation and training are carried out together, and the guns loaded simultaneously. But in view of the necessity of being able to attack at very long ranges, the author would substitute for the two 6-inch guns in many cruisers a 7.5-inch weapon firing a projectile of double the weight of the 6-inch at more than double the energy.^a From such a single gun a greater rate of fire would be obtained than is possible with the twin 6-inch guns, because the close proximity of the two guns must hinder operations greatly. The advantage gained by utilizing the heavier projectile at long range would fully compensate for any advantages of the twin guns of lighter caliber.

Fig. 27 illustrates the 6-inch twin quick-firing gun barbette mounting, of which the following is a detailed description:

The two guns are arranged close together in one cradle; they are mounted on a turntable carried on live rollers, and are protected by an armored shield secured to the upper surface of the turntable.

The turntable A is built up of steel plates and angles well riveted together; on the upper face of the turntable suitable machined faces are provided for the attachment of the brackets G, supporting the mounting. The upper roller path *a*, of special forged steel, is riveted to the under face of the turntable, and machined up true in position. The lower roller path *b* is secured to a machined surface on the floor of the barbette.

^aSince this was written it has been announced that the admiralty have decided to make this change in the six new cruisers of the *Monmouth* class to be built.

Rollers B of special forged steel support the turntable; they are provided with flanges on both sides to take the horizontal thrust; they are bound together by a ring of plate steel, to which the roller axles are secured, the whole forming a live roller ring.

The turntable is arranged to be rotated both by hand and electric gear. A vertical shaft C carries a pinion F at its lower end, gearing with the training rack E attached to the lower roller path. On the same shaft the necessary gear is provided for connection to the electromotor and to the hand gear. Provision is also made so that only one form of power can be in operation at the same time.

The electromotor N is of the armor clad, water-tight, shunt-wound type. It is controlled from the sighting stations at each side of the mounting.

Handles P are provided for men at the rear of the turntable behind the guns. They are connected to a worm wheel on the vertical training shaft by means of suitable gearing.

The mounting consists of the forged-steel cradles S of semicircular section, with bronze bearing strips at front and rear securely bolted together. Forged-steel caps R are fitted over the front parts of the cradle to retain the guns and to facilitate removal. The cradles are provided with trunnions *g* arranged to rest on brackets G built up of steel plates and angles and steel forgings.

The elevating arc is placed below the guns, the upper end being attached to the rear part of the mounting, while the lower end is connected by forged-steel links to the front of the cradles between the guns. A pinion on a transverse shaft below the guns is provided for actuating the guns. The outer end of the shaft is furnished with a worm wheel attached to the shaft by means of friction plates. The worm which gears with the wheel is arranged to be worked by two handwheels *p* at the sighting stations, one on either side of the mounting, and from a secondary handwheel *q*. Independent recoil cylinders and run-out springs are fitted for each gun.

The recoil cylinders H are of cast manganese bronze and are rigidly attached to the underside of the gun cradles. They are constructed to unite in the center between the guns and are bound together with securing bolts at the junction.

The piston rods are of forged steel attached to the lug on the gun. An orifice in the piston provides for the passage of liquid from one side of the piston to the other when the gun recoils after fire.

Two recuperator springs K are provided for each gun, placed one on each side of the recoil cylinder; they are of sufficient power to insure the gun running out at all angles of fire, even with a considerable heel of ship.

Two sighting stations are provided, one on each side of the mounting, with handwheels arranged so that the guns can be operated from either side. The sights *s s* are supported by a rigid structure W from the floor of the turntable, independent of the mounting. An arm *w*, fixed to the gun cradle and moving therewith, operates the rear sight bar on each side.

To provide for the rapid supply of projectiles a carrier D is arranged inside the barbette, outside the turntable, and connected thereto by means of suitable gearing. This gearing is arranged to rotate the carrier ring, bringing the projectiles underneath the openings provided in the gun platform so that they can be readily transferred to the breech of the gun for loading. The carrier ring shown on the drawing is arranged to carry 153 projectiles.

Provision is made for a constant supply of powder charges from the magazines to the gun platform. A chain hoist Y, with suitable receptacles *v*, is arranged to take up the powder charges in a horizontal position. The chains are arranged to pass over sprocket wheels at the top and bottom of the revolving trunk T attached to and revolving with the turntable. The charges are delivered at each side of the gun mounting. On one side they pass over the sprocket wheels, and are received in an inclined tray. An auxiliary chain and tray, driven at a greater velocity than the

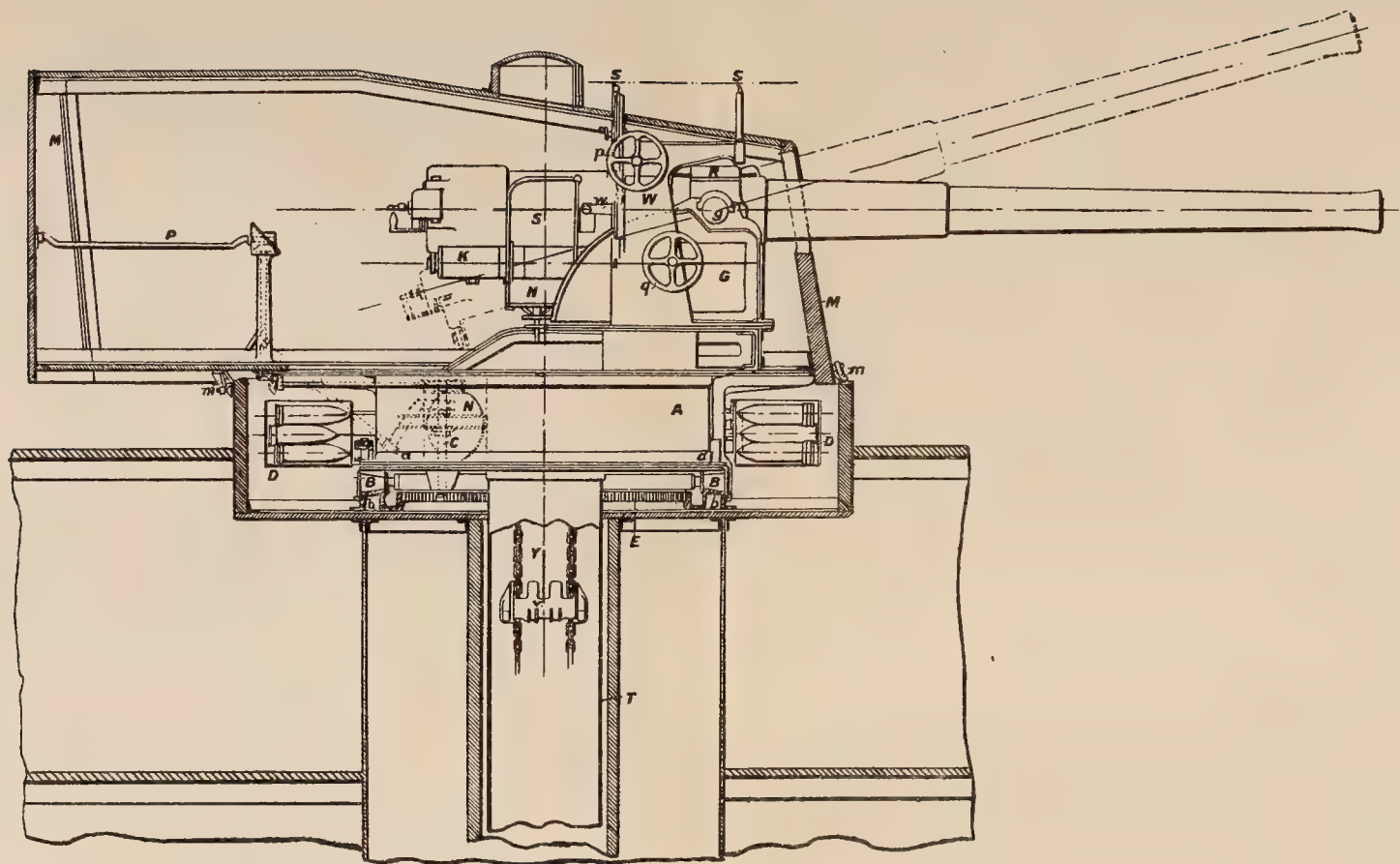


FIG. 27—BARBETTE MOUNTING FOR TWO 6-INCH GUNS.

Fig. 28.

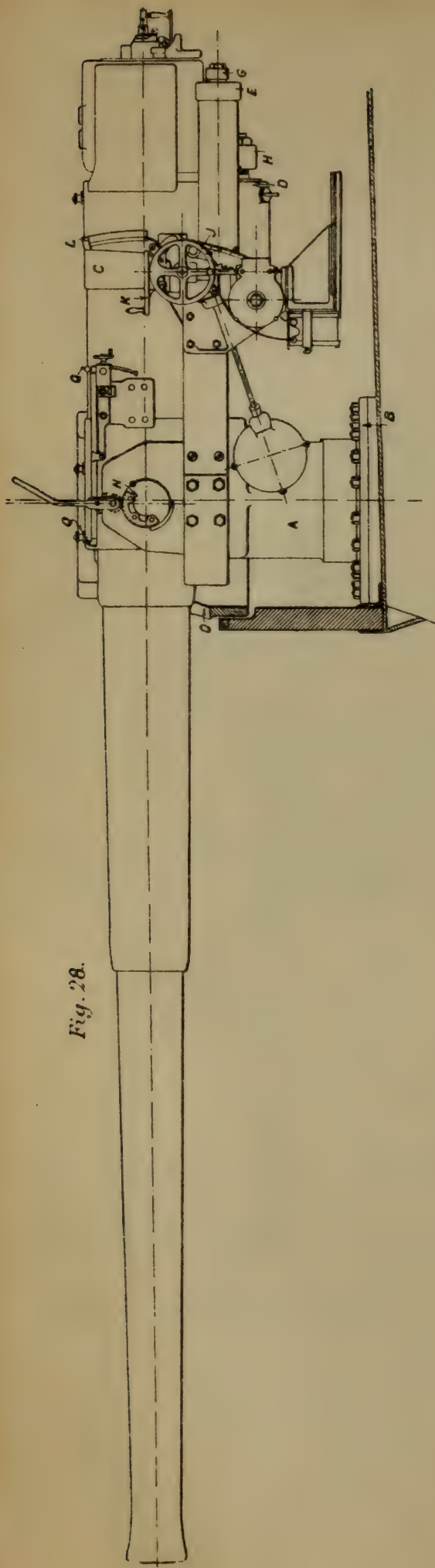
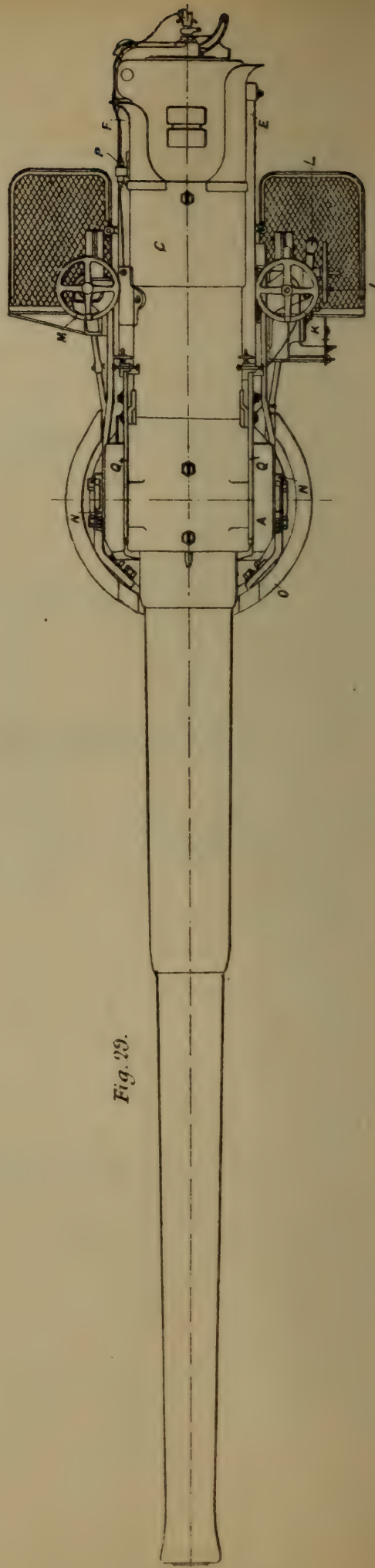


Fig. 29.



FIGS. 28 AND 29.—CENTRAL PIVOT MOUNTING FOR 6-INCH, 50-CALIBER, Q. F. GUN.

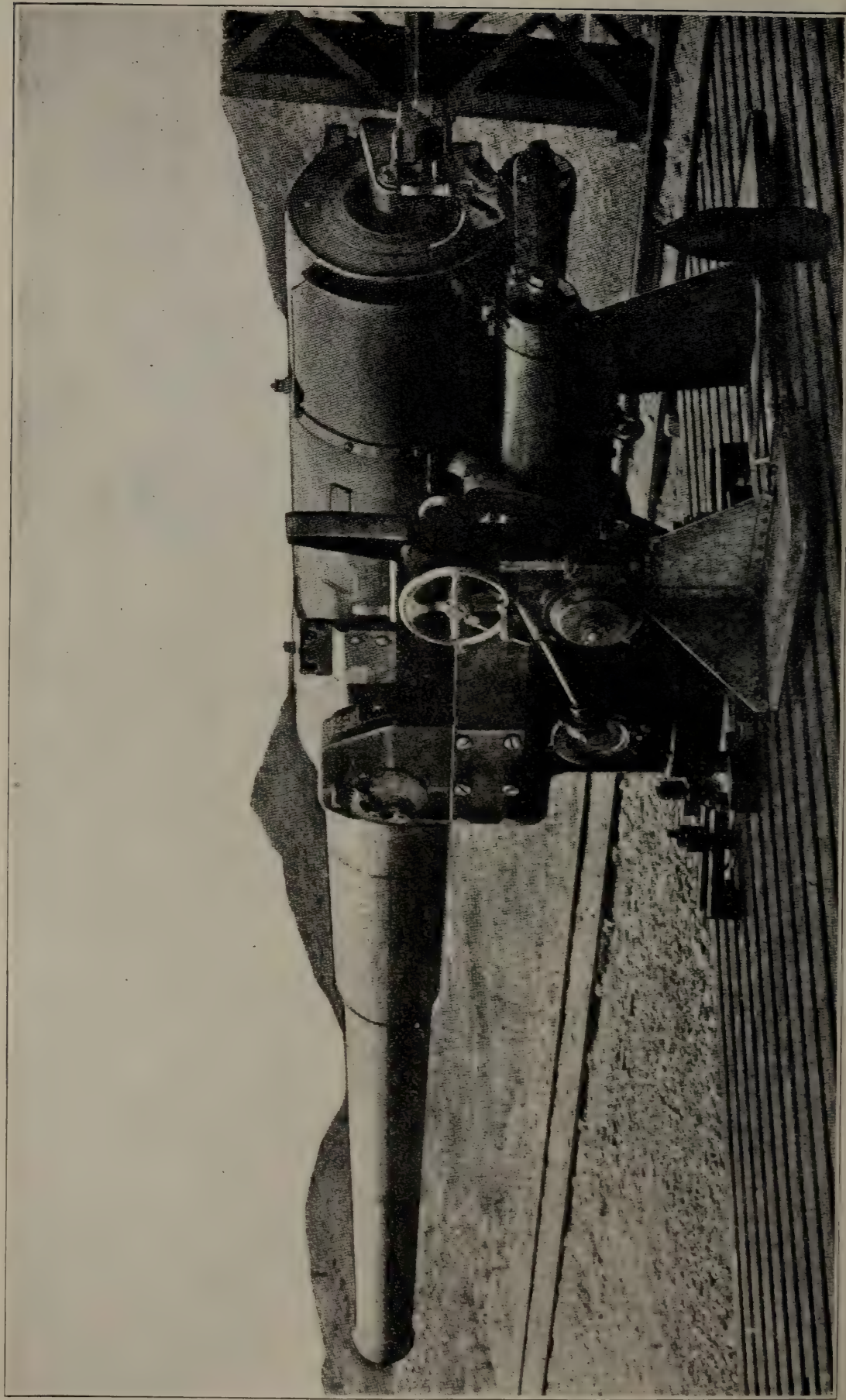


FIG. 30.—CENTRAL PIVOT MOUNTING FOR 6-INCH .50-CALIBER Q. F. GUN.

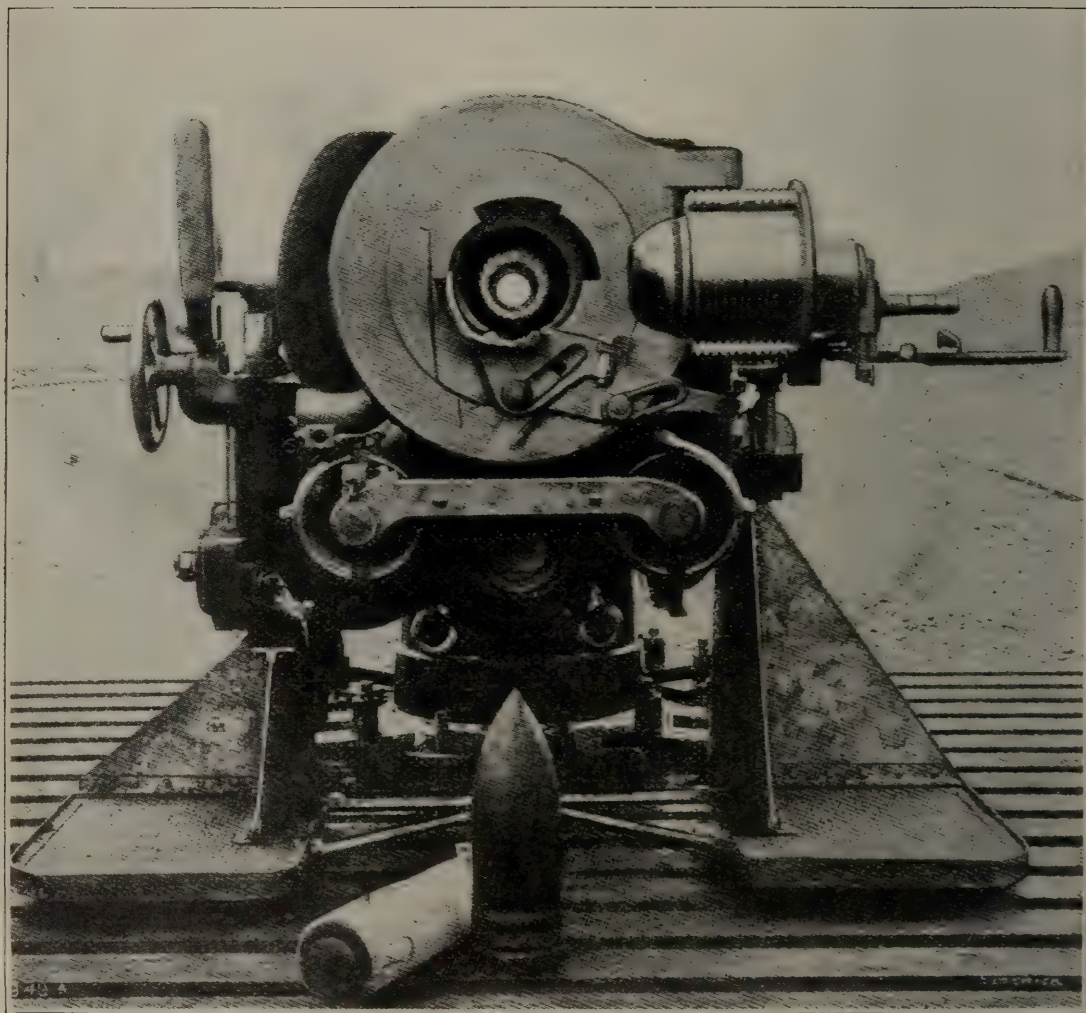


FIG. 31.—6-INCH GUN, CENTER PIVOT MOUNTING.

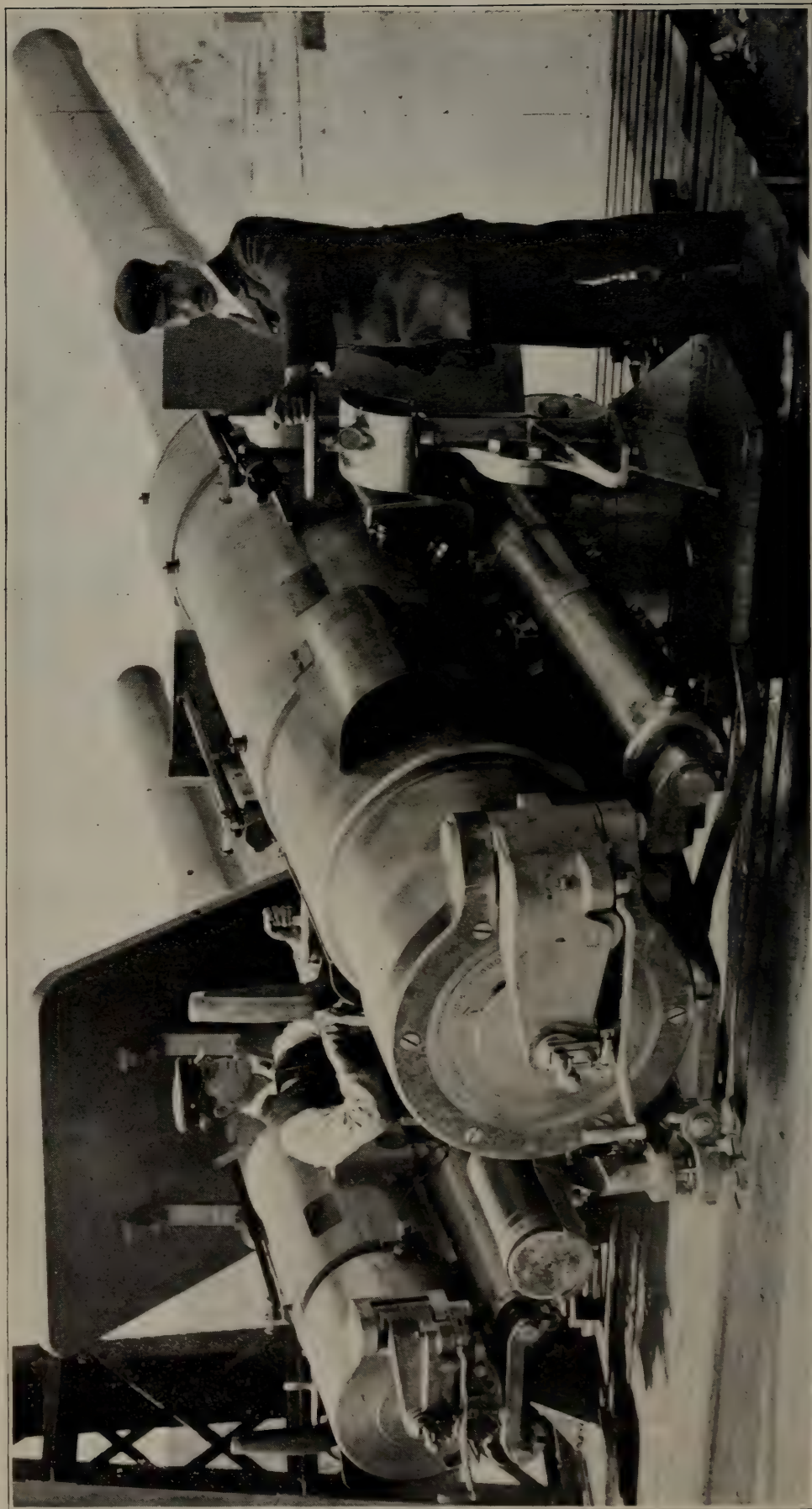


FIG. 32.—VICKERS 6-INCH AND 7.5-INCH Q. F. GUNS ON PEDESTAL MOUNTINGS.

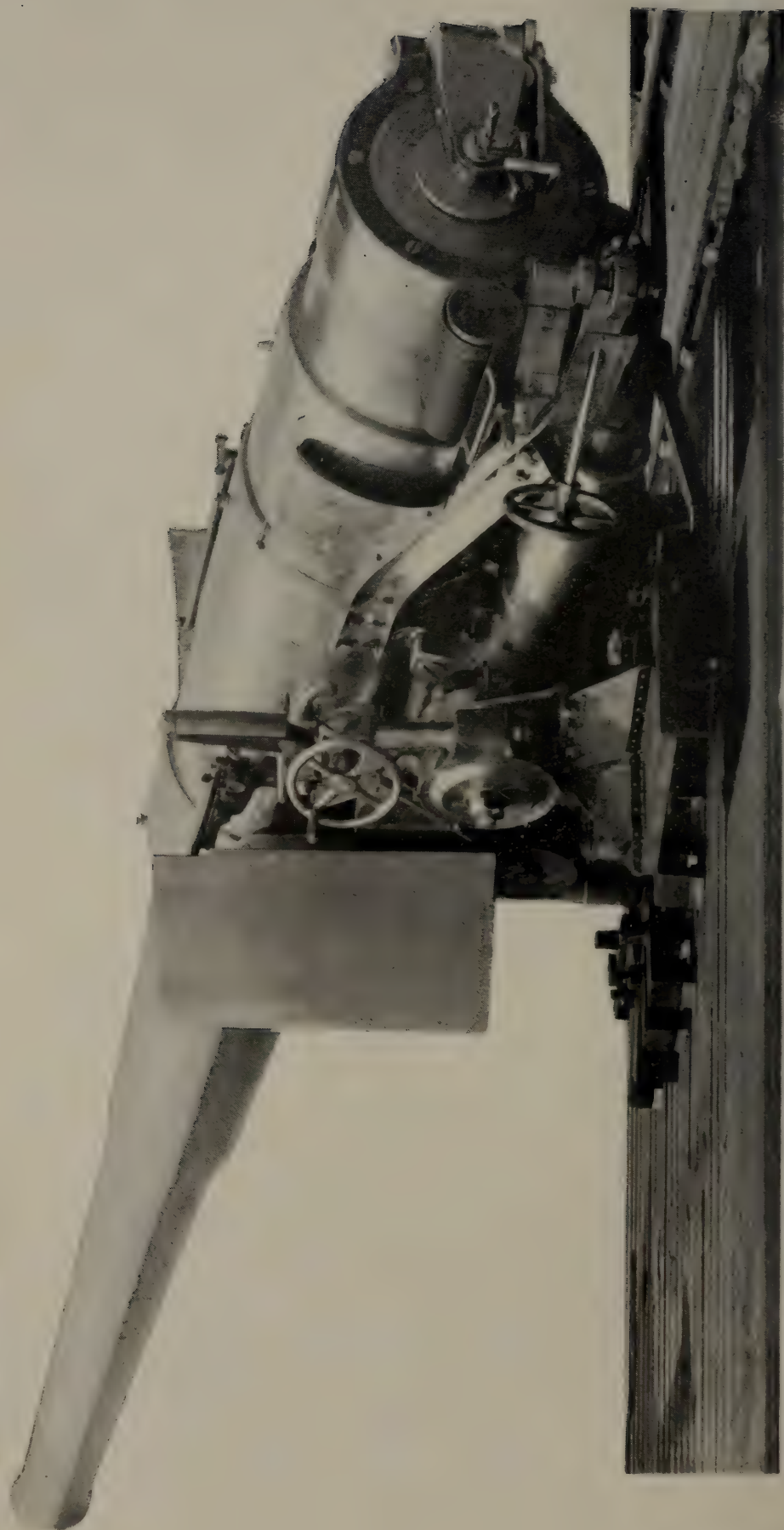


FIG. 32*a*.—VICKERS 7.5-INCH WIRE-WOUND GUN.

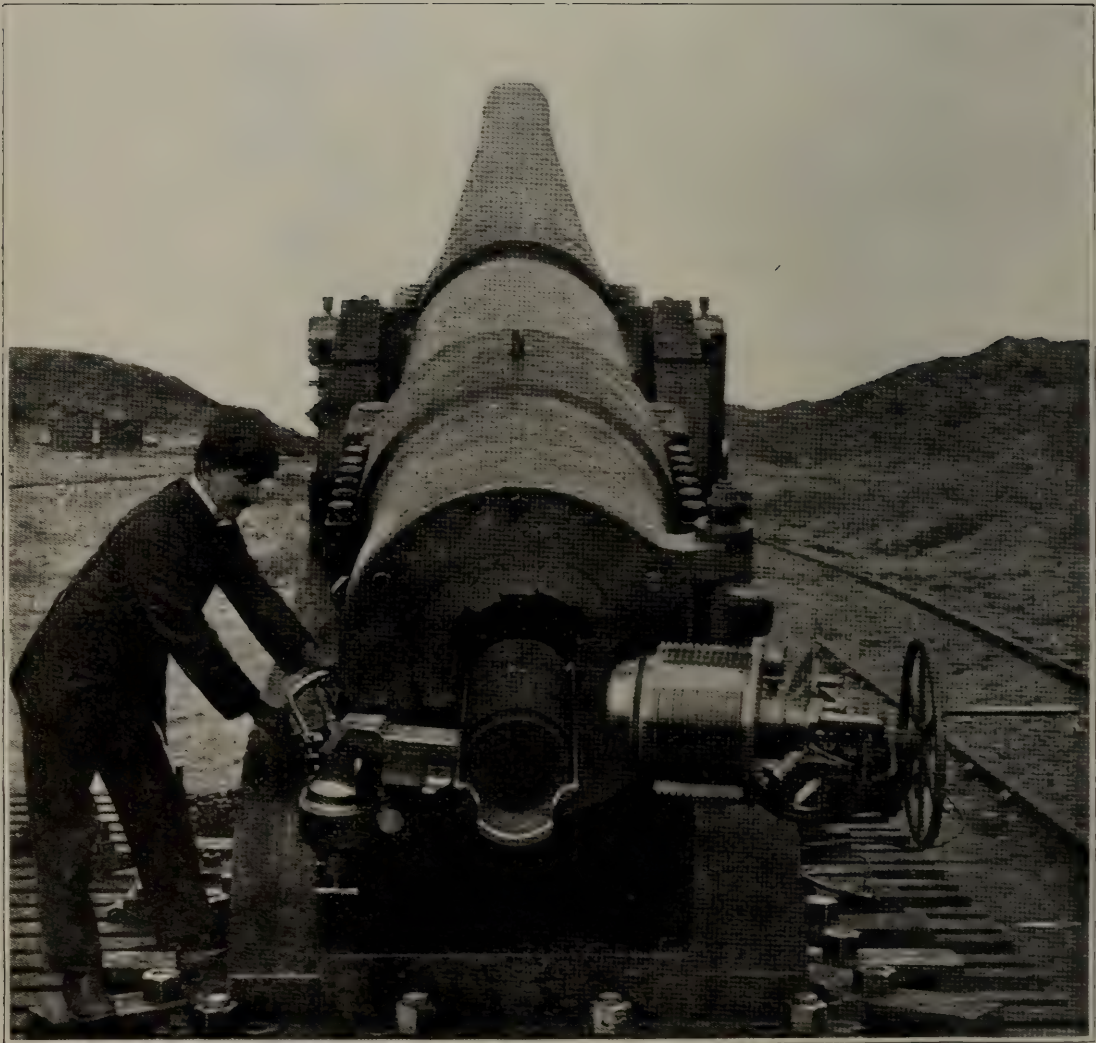


FIG. 33.—9.2-INCH WIRE-WOUND GUN WITH LOADING TRAY.

hoist, lifts every alternate charge and delivers it on the opposite side of the gun mounting. If necessary, projectiles could be arranged to be carried in every alternate receptacle, so that the latter might be delivered on one side of the mounting and powder charges on the other side. The hoist is actuated by means of an electro-motor situated at the base of the revolving trunk, with all necessary attachments and gearing.

The mounting is inclosed by an armored shield M, securely attached to the upper floor of the turntable by a suitable steel angle-bar frame. The shield is fitted with a leather apron *m*, with suitable screws and brackets for making it water-tight with the barquette. Two sighting hoods are provided.

Center-pivot mounting.—Reference may next be made to the center-pivot mounting, largely adapted for quick-firing guns, and of which a typical example, constructed by Vickers, Sons & Maxim, for the Japanese Government, is illustrated by figs. 28 and 29, while in figs. 30, 31, 32, and 33 there are reproduced photographs taken of several guns during the firing trials at the Vickers ranges at Eskmeals. Figs. 30 and 31 show the 6-inch gun on the center-pivot mounting, fig. 32 affords a comparison between the 6-inch and 7.5-inch guns, the latter having double the power of the former, while fig. 33 shows one 9.2-inch gun.

The 6-inch quick-firing pedestal mounting, illustrated in detail on figs. 28 and 29, is typical, and may be fully described.

The mounting consists of a steel top carriage A, which rests on a horizontal ball-bearing on top of a hollow steel pivot B, on which it may be revolved. The gun is free to slide during recoil in a cylindrical cradle C, which is balanced on its trunnions in suitable bearings in the carriage. Underneath the cradle are attached three cylinders—one, D, to overcome the recoil, and the other two, E and F (one on each side of the recoil cylinder), containing the springs for running the gun up to the firing position after the recoil. The connection between these three cylinders and the gun is made by arms G and H projecting from the breech ring of the gun. The whole weight of the revolving parts, gun cradle, and carriage is balanced on the ball bearing, thus the training is very easy. The elevating and training operations are performed by the rotation of two handwheels, J and K, conveniently arranged with regard to a shoulder piece, L, against which the gunner may lean.

These two handwheels, J and K, are situated on the left-hand side of the mounting; but an auxiliary training handwheel, M, is provided on the right-hand side, so that two men may be employed to train the gun if desired. The training gear is arranged so that it may be easily and quickly thrown in or out of action.

The recoil cylinder D is of usual construction to give an approximately uniform pressure during recoil, and to control the speed of running out of the gun after recoil.

Provision is made for readily mounting and dismounting the gun, and to allow for this the trunnion bearings N and N are made in the form of circular caps, being so arranged that a partial rotation of the caps frees the trunnion of the cradle, so that the gun and cradle together may be drawn directly to the rear without any lifting being necessary.

The shield O is of the usual casemate type.

An electric contact P is fixed on the cradle, and is so arranged that unless the gun is fully run out to the firing position, it is impossible to fire the gun electrically.

Sights Q Q are provided on both sides of the mounting.

GUNS TO REPEL TORPEDO AND SUBMARINE BOAT ATTACK.

The 14-pounder semi-automatic gun.—Of the type of naval ordnance specially used for repelling submarine and torpedo attacks, including weapons firing 3-pounder, 6-pounder, 12-pounder, or 14-pounder shot, the 14-pounder now adopted by the United States Government is a typical example. Torpedo or submarine boats attacking ships or fleets at anchor would do so at very long range, and would probably

commence to fire their torpedoes from a range of nearly 2,000 yards. The guns for repelling such attack would have to be of power sufficient to stop the boats before they came within striking distance of their quarry. The United States Navy have therefore done the right thing in utilizing a shell of at least 14 pounds weight. Such a shell is certainly superior for dealing with high ballistics at long ranges, and is about the weight generally adopted as a minimum by most countries for their land-service artillery.

This 3-inch (14-pounder) semi-automatic quick-firing gun is illustrated by figs. 34 and 35; the semi-automatic breech mechanism is shown on figs. 36 to 38.

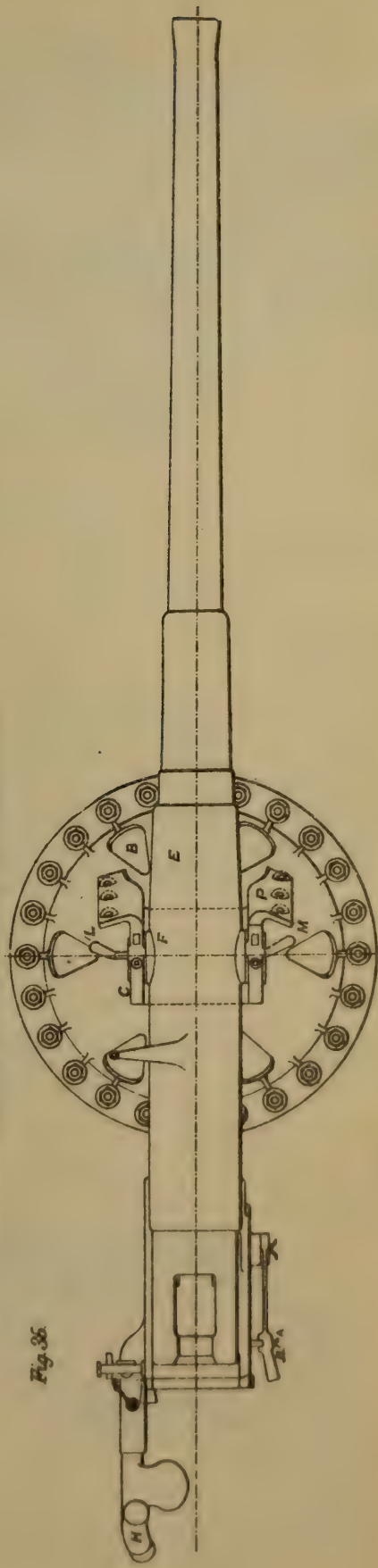
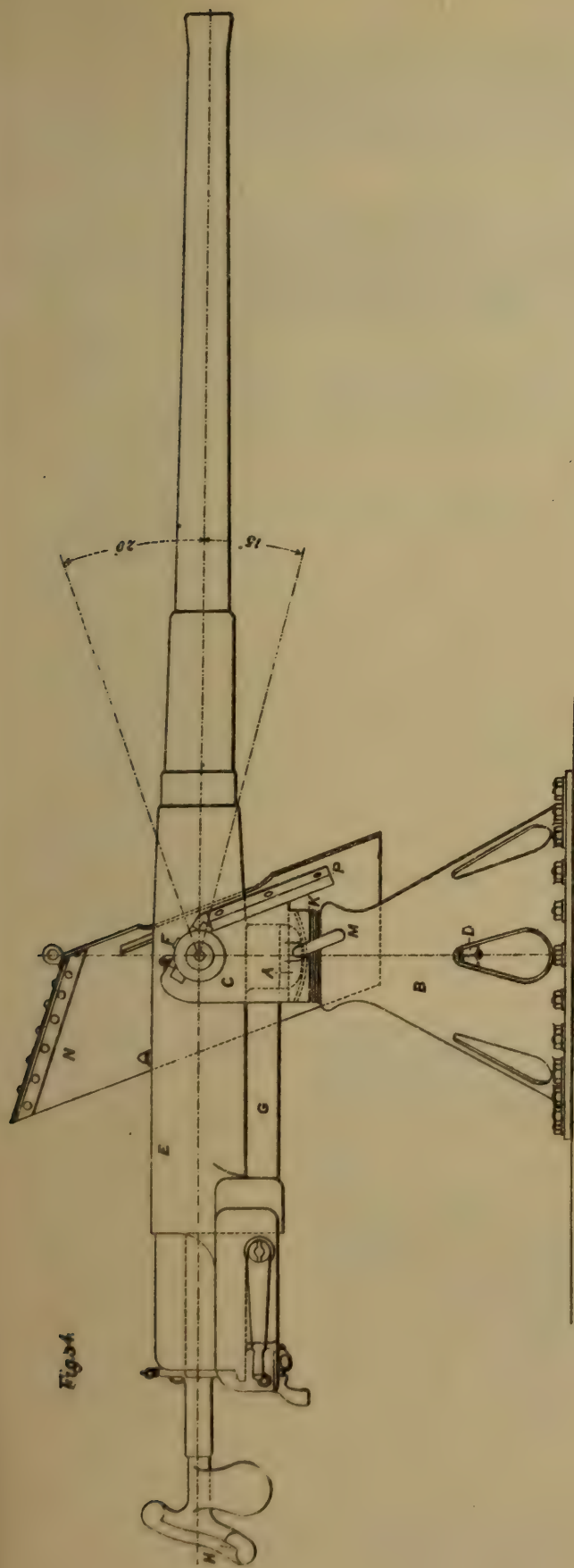
The mounting consists of a pivot A, which works in a steel cone or naval stand B, and has its upper part formed into a crosshead C. The cone is provided with gun-metal liners, and the pivot is secured to it by means of a pivot nut D. The cylindrical cradle E, in which the gun is free to slide in recoiling, is supported by trunnions F, in bearings formed in the crosshead; and it is provided with two hydraulic buffers G, in which work pistons attached to a lug on the underside of the breech end of the gun. The elevating and training are effected by means of a shoulder piece H attached to the cradle. The crosshead is fitted with a clamping screw, and a traversing clamping segment which fits into a groove K in the liner. When tightened by means of the handle L, this segment secures the gun in any required position of training. A similar handle at M clamps the gun at the desired degree of elevation.

Protection is afforded the gunner by a shield N, which is bolted to flanges P, forged on the cross-head jaws. The cylinders of the hydraulic buffers are provided with tapered grooves, which allow the oil to escape round the piston heads, and so regulate the flow that a constant pressure is maintained during recoil. Inside the cylinders are strong spiral springs surrounding the piston rods, which, being compressed by the rear motion of the piston heads, cause the gun after firing to return to its former position.

The breech mechanism for 3-inch (14 pounder) semi-automatic quick-firing gun is shown on figs. 36 to 38, and may be described in detail.

The gun rests in a cradle provided with two combined hydraulic and spring buffers, the piston rods of which are connected to a projection at the breech end of the gun. In the rear of the cradle A is a pistol grip B which contains the trigger C, and on the right-hand side is a detachable lever D, by the movement of which the breechblock E can be lowered or raised. The breechblock is capable of vertical movement, and contains the mainspring F, firing pin G, sear H, and cocking lever I. Situated between the buffers, underneath the cradle, is a powerful flat spring K, the action of which works the breech mechanism.

To prepare the gun for firing the breech is opened by the movement of the hand lever D, the handle of which is made to rest in a crutch prepared for its reception. By the movement of the hand lever a crank M is turned, the action of which brings down the breechblock E and compresses the powerful flat spring K situated between the buffers. At the same time the mainspring F is compressed, and is kept in this condition by the action of the sear H. The breechblock E in moving down strikes the lower extension O of the extractor and causes the upper portion to move out from the face of the end of the barrel, and brings two small projections P over the upper edge L of the breechblock E, thus preventing it from rising by the reaction of the spring K. The cartridge is smartly pushed into the bore, and as it goes forward into the chamber its rim strikes against the extractor and forces back the projections P, which prevented the breechblock from rising. The flat spring before referred to acts and rotates the crank M, thus raising the breechblock until the breech is closed. The tail end R of the sear is now engaged with the toe S of the trigger, and by pulling the trigger pull C to the rear the trigger releases the sear, and the firing pin G is thrown forward by the action of the mainspring F. On the pulling of the trigger the gun is fired, and recoils in the cradle; the recoil, which is controlled by



FIGS. 34 AND 35—THREE-INCH (14-PDR.) AUTOMATIC QUICK-FIRING GUN.



Fig. 36

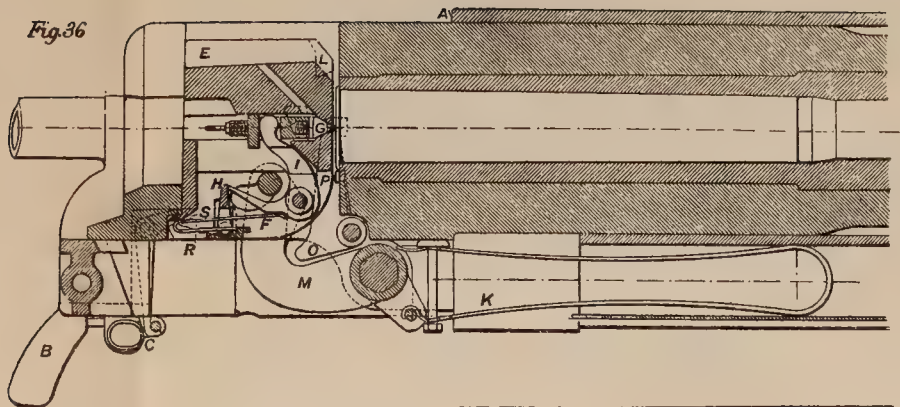


Fig. 37.

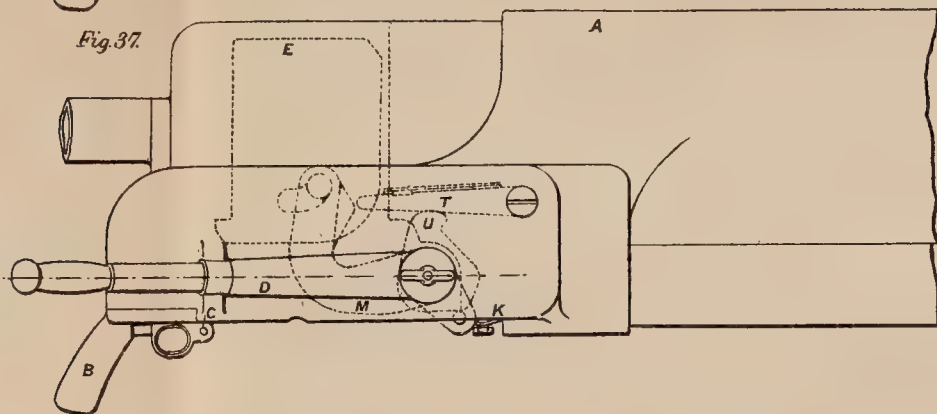


Fig. 38

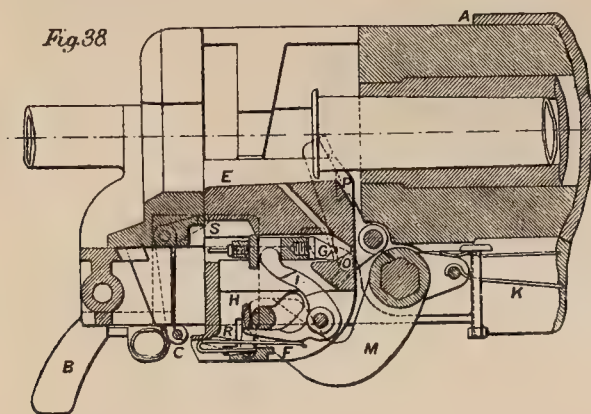
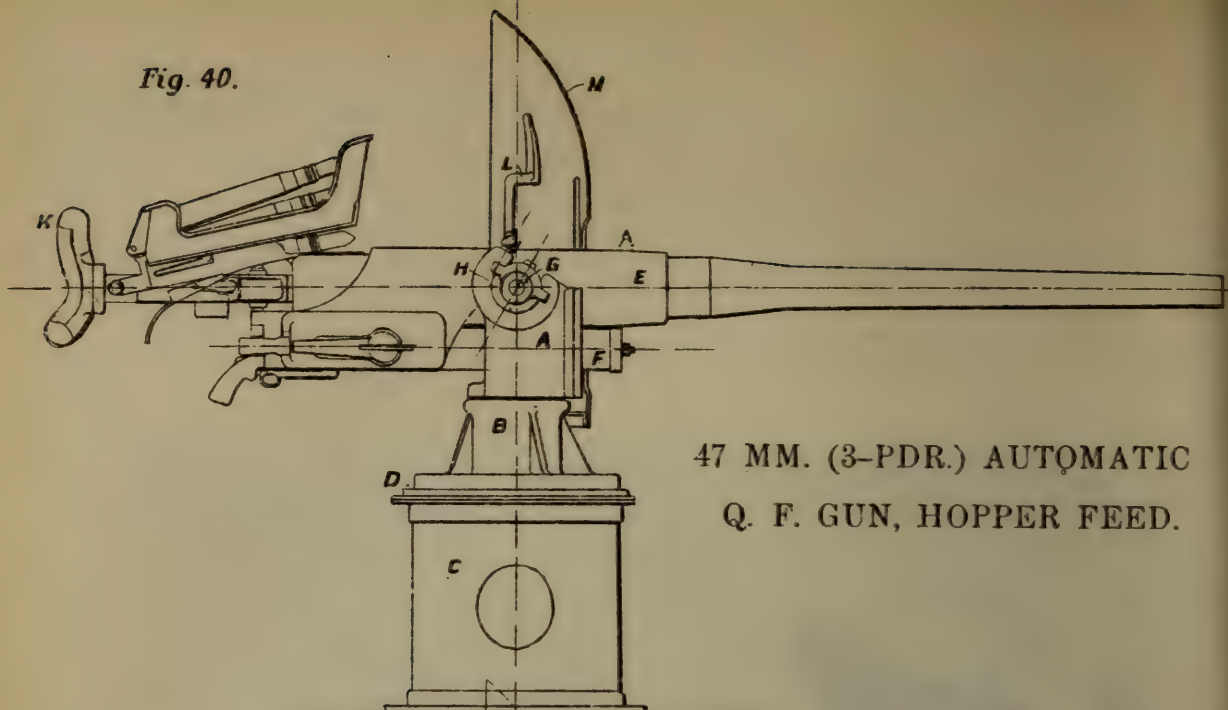






FIG. 39.—3-POUNDER AUTOMATIC GUN WITH HOPPER FEED.

Fig. 40.



47 MM. (3-PDR.) AUTOMATIC
Q. F. GUN, HOPPER FEED.

Fig. 41.

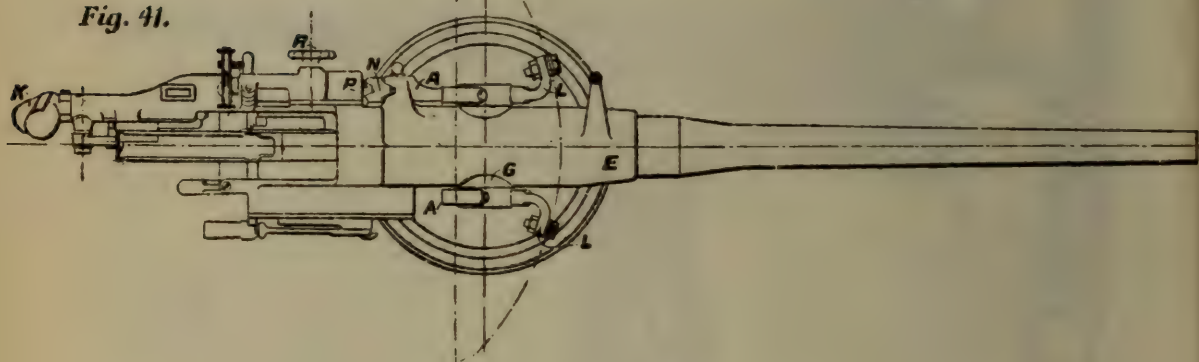
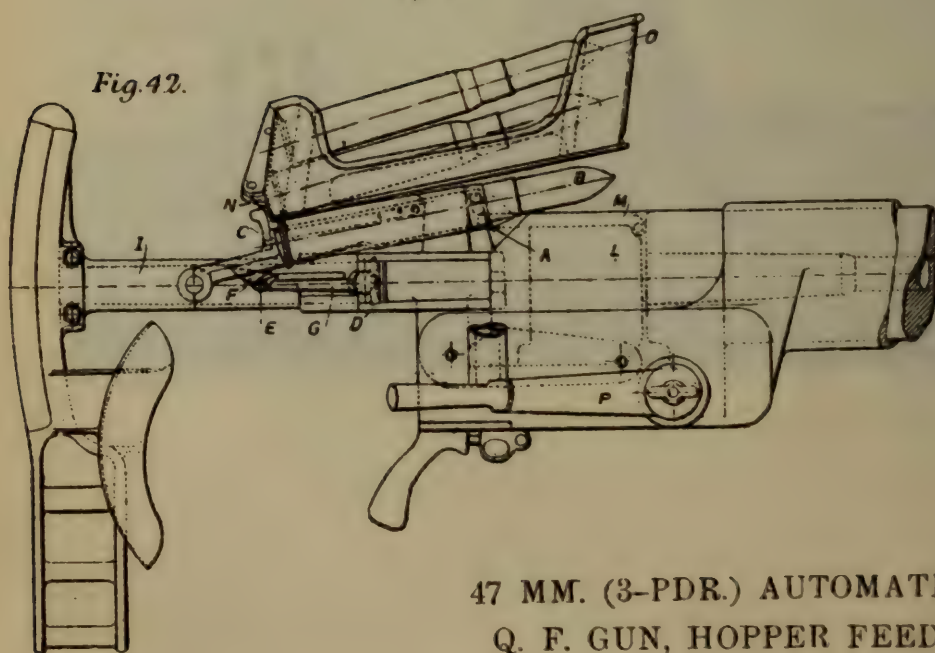
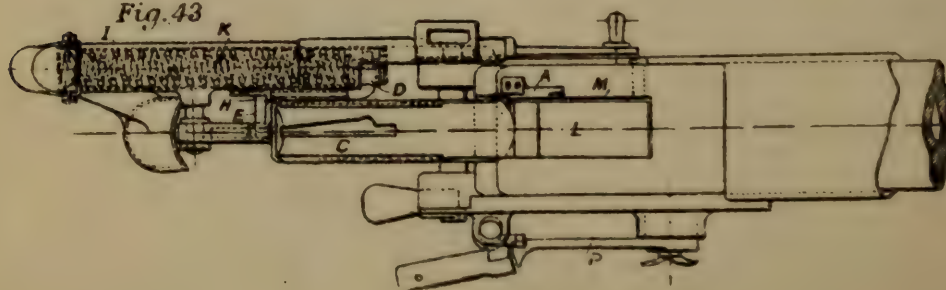


Fig. 42.



47 MM. (3-PDR.) AUTOMATIC
Q. F. GUN, HOPPER FEED.

Fig. 43



the hydraulic buffers, compresses the powerful springs round the piston rods, and the reaction of these springs at once returns the gun into its original position in the cradle. As the gun returns, the action pawl T engages the hook U on the crank M, which causes the crank to rotate, and thereby bring down the breechblock. The extractor is actuated upon by the fall of the block; it first loosens the cartridge by a slow movement, which, rapidly increasing, finally ejects it to the rear.

The 3-pounder automatic gun.—Another type of gun for resisting torpedo-boat attack, namely, the 3-pounder, is one which at the present moment calls for much study. The gun selected for general description is one now being extensively used in the United States Navy, although the automatic device is at the present time only under experimental trial. The naval mounting for this 47-millimeter (3-pounder) automatic quick-firing gun is illustrated by fig. 39, annexed, and by figs. 40 and 41, and the following is a detailed description:

This mounting consists of the crosshead A formed in one piece with a pivot turning in the socket B, which is supported by a cylindrical base C, and is secured thereto by a holding-down ring D.

The cradle E, through which the gun recoils, is provided with an hydraulic buffer F, in which works a piston attached to a lug on the breech end of the gun. On the cradle are forged the trunnions G, which are supported in bearings H formed in the jaws of the crosshead.

The elevating and training of the gun are performed by means of the shoulder-piece K, which is attached to the cradle. Attached to the crosshead is the elevating segment N grooved to receive the clamping bar P, which is attached to the cradle. This bar being tightened in the groove by means of the wheel R, the gun is fixed at the required elevation. A clamping screw is also provided in the socket B, which holds the pivot at any point of training.

A pair of arms L L, forming extensions of the crosshead, carry the shield M, which protects the man working the gun.

The cylinder of the hydraulic buffer is provided with grooves which allow the oil to escape round the piston head and so regulate the flow that a constant pressure is maintained during recoil. Inside the cylinder is a strong spiral spring surrounding the rod, which, being compressed by the recoil, causes the gun to return to its former position.

The hopper-feed mechanism of this 47-millimeter gun is of great interest. It is shown in detail in figs. 42 and 43, and is thus described:

Directly the gun recoils it brings the carrier rest A under the lug B on the carrier C, and does not leave it until the gun has returned to its firing position, the carrier C can therefore under no condition descend until the gun is home. During the recoil, the face of the barrel breech forces the plunger D, with its pawl and feeder E, back until the hook F on the pawl G passes the lug H on the shoulder piece I. The pawl is raised by its spring K, and the hook F engages with the lug H, thereby cocking the plunger piston D. The gun returns, and at a certain distance from home the action pawl, coming into play, opens the breech, and the ejection of the empty case begins.

When fully home, the carrier C descends, being clear of the carrier support A, and after being moved a certain distance it engages with the part of the pawl forming the feeder E, depressing it, and finally disengaging the hook F from the lug H on the shoulder piece I.

The plunger piston spring K reacts and returns the plunger D, with its pawl and feeder E, to its original position, the feeder forcing the cartridge in the carrier forward, shooting it into the chamber.

The breechblock L, during its ascent, raises the lifting lever M, and through it the carrier C. When this latter is nearly home, it engages through the projection with the tail N of the escapement, and moves it out of the path of the cartridge in the

hopper O. The cartridge being thus liberated, slides through the hopper into the carrier, its place in the hopper being taken by the next cartridge, which in turn is locked by the escapement as the carrier descends, and is liberated on the return of the carrier.

To load the gun the following operations are necessary: Open the breech by depressing the hand lever P, and return it to its original position. Insert a loaded cartridge in the breech beneath the carrier, and send it home in the chamber by a quick forward push, as in loading an ordinary semi-automatic gun. The breech will then close automatically. Charge the hopper, and the gun is ready for firing.

The "pom-pom."—Guns to resist torpedo or submarine-boat attack must also include the "pom-pom," now almost universally adopted as a high-power automatic firearm specially applicable as a personal deterrent, when searching out for gun crews or others doing important duty on board torpedo vessels, or any warship, and not protected by armor. The rate of fire of the gun is about 250 rounds per minute, and each shell, weighing about $1\frac{1}{4}$ pounds, bursts on impact into about 13 pieces. Such a gun, it will be recognized, is specially suitable for attacking gun crews in the fighting tops, etc., the hail of shell rendering it impossible for the men to remain exposed at their guns. When the German ships were recently attacking the Chinese forts at Taku, the "pom-pom" drove the gunners away from the fort weapons, leaving them to be put out of action by the heavier caliber quick firers on board the ship. Our Admiralty would therefore be well advised to have a few of these "pom-poms" on board every ship for such special duty, particularly as they can be utilized on landing carriages, in addition to sea service or attack on coast defenses. The experience during the Transvaal war has specially demonstrated their value as naval-landing guns. The general arrangement of their mechanism is similar to the rifle-caliber Maxim gun.

PROJECTILES AND PROPELLING POWDERS.

The question of projectiles for modern naval artillery is receiving the greatest attention in all countries. Nearly ten years ago the Russian Government commenced experiments with capped projectiles, and demonstrated their advantage; recent developments in this country have led to their being ordered for use with guns of 12-centimeter caliber and upward. For many years the French have utilized caps in connection with armor-piercing shell. Recent developments in Germany show that they are also about to use capped projectiles, and Messrs. Krupp, of Essen, are recommending one of their own construction, which greatly improves the armor-piercing capacity of the shell. The author, from experience, greatly favors the application of a cap to all armor-piercing projectiles for use against modern armor, although the advantages of the capped projectile against comparatively soft armor are not realized to any serious extent.

The types of armor-piercing shell are so numerous that no attempt can here be made to enter into details; but the author believes so much in the importance of the really armor-piercing shell from a naval point of view—the penetration of a ship's side when the projectile hits being so supremely important—that no money should be spared to secure the very best obtainable. Really regular and reliable results are only to be insured by the best forged steel, and not from shells made from castings unforged.

The experiments carried out against H. M. S. *Belleisle* prove the destructive effect of the high explosive shells, if they penetrate through the armor or otherwise get into the interior of the ship, as described in last year's *Brassey's Annual*. The value of such shells against superstructures and the nonprotected upper works of the ship is very great; but the attack on such parts of a ship would not be in any way decisive, and the best way to really put a ship out of action is to perforate the armor near the water line, or to get a large number of projectiles behind the armored

protection. Such results are only possible by perforating the modern hard-faced armor, and it would therefore seem supremely important in all armor-piercing shells which are now being utilized that they should be made of such material as to insure their being able to perforate the most modern hard-faced armor without breaking up, as is at the present time more usual. This the author believes to be only possible by armor-piercing projectiles fitted with caps, and there is exhibited a 6-inch shell which a few weeks ago passed without injury through the latest type of 6-inch hardened plate with the very moderate velocity of 1,950 feet. A projectile so constructed and fitted with a cap would be able not only to pass through a 6-inch plate, but through a 12-inch plate should the necessary energy be given to the projectile, and the author has already indicated how such increased energy may be attained, even in our existing naval artillery. A semi-armor-piercing shell properly constructed and fitted with a cap would also have much greater powers of penetration than the existing semi-armor-piercing shell without a cap, and it would appear desirable that the largest portion of the projectiles carried on board all ships should be constructed of sufficient strength and fitted with caps so as to be capable of perforating modern armor, such as will be found on the ships of all possible opponents. From 70,000 to 80,000 tons of this armor is made annually for the navies of the world.

Next in importance to the armor-piercing or semi-armor-piercing shell come the large-capacity shells carrying a high explosive. For this purpose Germany and France, like Britain, make use of picric acid, but the Russian Government are utilizing gun cotton in shells up to 11-inch caliber.

In regard to propelling powders for guns, there is not much difference of opinion, except in Great Britain, as to the most suitable compound; most countries have adopted or are about to adopt a nitrocellulose powder. For use with rifles, England, Italy, and Norway may be said to be the only countries now using a nitroglycerin composition of powder, whereas Germany, Austria, France, Russia, the United States, Spain, Denmark, Roumania, and the Spanish-American States utilize entirely a nitrocellulose compound. In regard to the explosives used for heavier artillery, Great Britain, Italy, and Austria are the only countries which have permanently retained the nitroglycerin form, whereas Germany, France, Russia, the United States, Spain, and Japan utilize nitrocellulose powder.

The most important considerations in determining the best composition of powder to be adopted are: Firstly, its keeping qualities and safety under normal climatic conditions; secondly, its capability of obtaining the highest possible ballistics, and consequently the flattest trajectory, and, thirdly, its regularity in results, so that the ballistics may not be seriously affected by change of temperature or by the wearing away of the gun due to excessive erosion. All these qualities are secured by the use of a properly manufactured nitrocellulose powder, whereas none of these conditions can be said to be met by any powder containing nitroglycerin.

At the present time the Russian Government manufactures the largest quantity of nitrocellulose powder. Up to about two years ago all the conditions enumerated were not fulfilled, owing to the nitrocellulose used for the powder not being quite satisfactory; but since then they have obtained the best results by using the system employed by the Cologne Rotweil Company at their factory at Schluselburg. In France and Russia also great difficulty was experienced at the outset in obtaining a really suitable nitrocellulose, and in carrying out the necessary operations to render the powder really homogeneous and safe. Indeed, it is only by careful study and much experiment that the manufacture of nitrocellulose powder has now become really reliable and stable. The most serious experimental work in connection with this matter has been carried out by the Cologne Rotweil Company, at whose establishment extensive chemical research is always in progress. The Russian Government realized this some years ago, and in consequence gave this company a large number of orders, rendering it possible for them to establish large works in Russia

for the development and manufacture of this highly important artillery necessity. Thus the average production in Russia of nitrocellulose powder, manufactured upon a Rotweil system, amounts now to about 400 tons per annum.

It is, in the author's opinion, the only suitable compound for use with high-power artillery, and as experiments have convinced the author that powders containing even a small proportion of nitroglycerin are unsuited to guns developing high velocity, he believes that the British authorities would be well advised in adopting the nitrocellulose compound.^a Difficulties, no doubt, would attend such change at the outset; but the wear of the guns at present, with all attendant disadvantages, makes the alteration almost imperative, especially when great power and rapidity of fire are sought for, as erosion increases at a much higher percentage with nitroglycerin and necessitates an exceptionally large reserve of guns being kept.

THE VELOCITIES ATTAINED BY MODERN GUNS.

This raises the question of the velocities and ballistics generally of guns, and appended are three diagrams. Fig. 44 shows the velocities, energies, and range of various types of 6-inch guns; fig. 45 gives a comparison of the dangerous space of the service 6-inch guns, and of the Vickers weapon of the same caliber, and fig. 46 a similar comparison for 12-inch breechloaders. The diagram of the 12-inch gun (fig. 46) shows well the value of increased velocity, the dangerous space of an object 30 feet high at a fighting range of 2,500 yards being increased by 162 yards in 523 yards when the muzzle velocity is accelerated from 2,500 to 2,700 feet per second. The former velocity is obtained with cordite (a nitroglycerin compound), and the latter with nitrocellulose powder. In the diagram of 6-inch guns the velocity of a gun firing at 3,000 foot-seconds is compared with the British gun now in most of our war ships, rather than with the latest type, which is now being put into all the new ships. In this case the dangerous space at 2,500 yards distance from the gun is increased from 226 yards to 465 yards for a target 30 feet high, which would represent the freeboard of a war ship or merchantman. These special cases establish the importance of high velocity in modern naval artillery, for at sea it is quite impossible to accurately judge distances at once, and such errors in range need not involve the missing of the ship if the guns were of the highest possible energy, which means low trajectory, and consequently an extended danger zone.

As to the diagram showing the curves of comparative energies of various types of 6-inch guns (fig. 44), it indicates that if the British gun makes use of a nitrocellulose powder giving a velocity of about 2,800 foot-seconds, it will be well ahead in energy of the 6.4-inch French gun, to which it corresponds. The 6-inch gun installed in the majority of our ships, however, is not nearly so powerful as this particular weapon, as evidenced by the diagram. This great discrepancy in power could be eliminated even with these old-fashioned guns by slightly enlarging the chamber and by utilizing a nitrocellulose powder instead of cordite. This simple modification would result in the main armament of the majority of our battleships and cruisers being greatly improved.

THE HOTCHKISS 1-POUNDER (37 MM.) AUTOMATIC GUN.

The 1-pounder automatic machine gun is based on the same principle as that of the Hotchkiss rifle-caliber, machine, gun, but the details of the mechanism have been greatly modified in order to simplify the construction and strengthen the breech closure. All of the motions of the mechanism are parallel to the axis of the gun, and the accuracy

^aA new powder known as cordite M. D. has been tried since this paper was written. Its results are not entirely satisfactory to the British naval service.

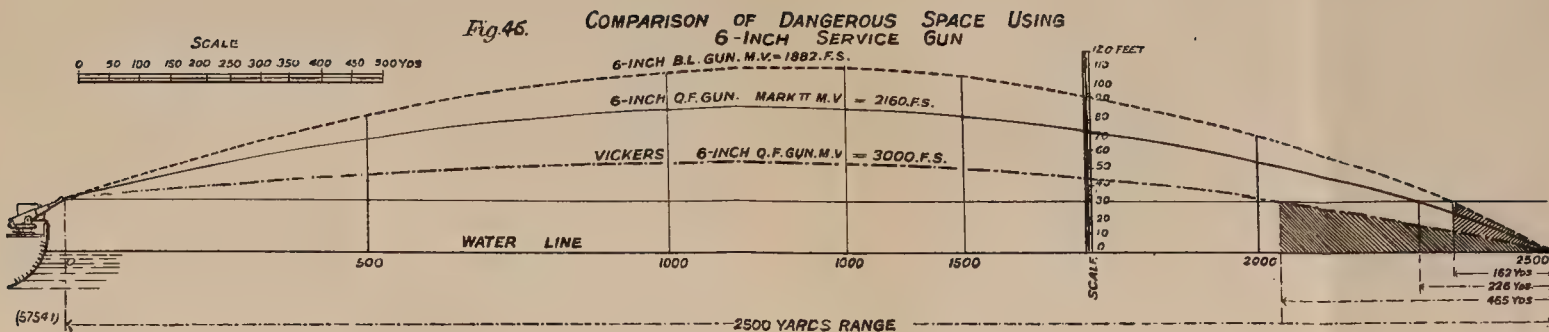


Fig. 44.

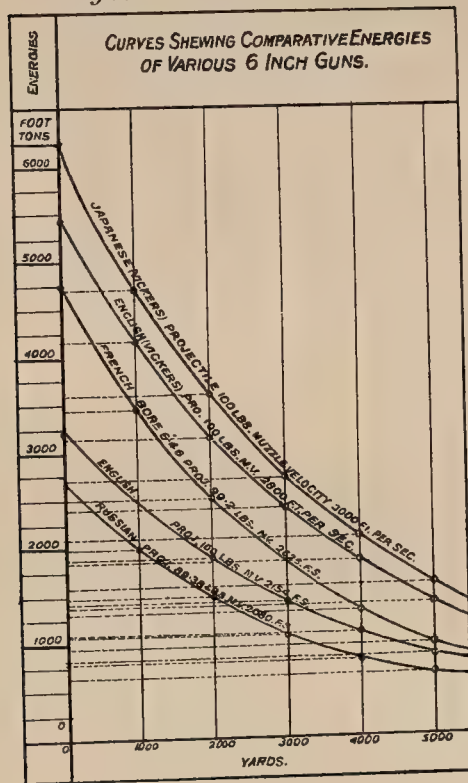
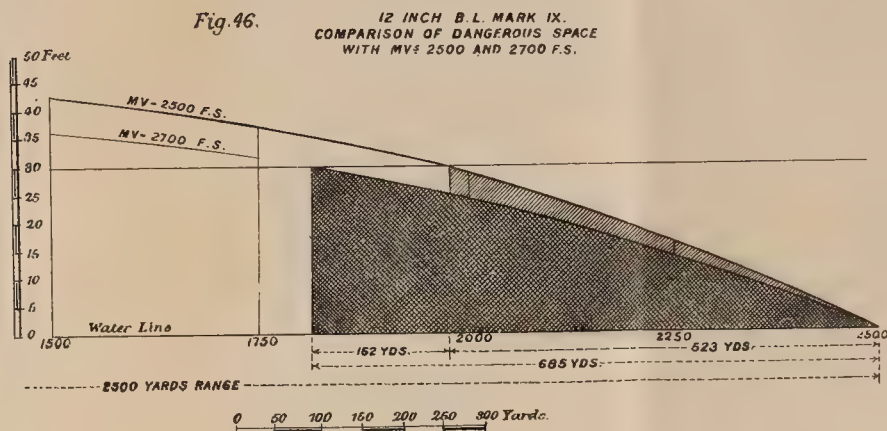


Fig. 46.



of fire is not affected by the vibration. The entire mechanism may be completely dismounted, or assembled, without the use of tools, and has been designed that it may be operated and cared for by an enlisted man of ordinary intelligence.

The firing gear is arranged for firing single shots, or continuously, at will, the rate of feed in the latter case attaining 200 rounds per minute. The gun is loaded by means of feed strips holding 8 or 10 rounds, or by belts of 25 or 50 rounds. The rate of fire is the same for both methods of loading, the strips being recommended except when the gun is mounted in a confined position, such as in boat service, small turrets, and the like. Both strips and belts are made wholly of mild steel, and may be employed indefinitely without re-forming, and being entirely metallic, are not affected by water and climatic conditions. The feed mechanism is positive and independent of gravity, and is not influenced by the elevation or depression of the piece.

The cartridges are not fed into the chamber until the instant of firing, and consequently are not subjected to excessive temperature in case the firing is suspended with the gun loaded. The barrel is fitted with a radiator, which absorbs a great portion of the heat developed by the powder and obviates the necessity of a water jacket.

GENERAL PRINCIPLE.

A gas port is drilled into the barrel of the gun a few calibers from the muzzle, and brings the bore into communication with a cylinder parallel to and beneath it. Within the cylinder is a piston, and when, on the discharge of the gun, the projectile passes beyond the gas port, the powder gas enters the cylinder and throws the piston to the rear. The rearward motion of the piston compresses the mainspring, and this, when not prevented by the trigger, immediately returns the piston to its original position. The remaining parts of the mechanism are actuated by this reciprocating piston, and perform the operations of opening and closing the breech, extraction and ejection of the empty cartridge case, feeding, loading, and firing.

DETAILED DESCRIPTION.

Receiver.—The receiver is a single gun-metal casting and contains all of the mechanism. To the front it is threaded to receive the breech piece B. In the interior are worked a passage for the piston head F¹, two longitudinal guides for the locking lugs N¹, N¹, of the breech-block, and a passage for the piston F². To the rear the receiver is closed by the breech cover A¹, which is secured by the pin A². On removing the pin the breech cover may be swung open and all of the mechanism exposed. The shoulder piece is seated in the breech cover

and may be removed at will. The feed block, V, is mounted in the receiver from the right, and is secured by two pins v^1 , v^1 . On the left is mounted the deflector S^1 , which may be swung about the pivot S^2 , and removed, exposing the ejection opening.

Breech piece.—The breech piece B is screwed into the front of the receiver, and is provided with a seat b^1 for the head of the breechblock. To the front are formed the rings b^2 , b^2 , for the absorption and radiation of the heat developed by the powder gas.

Barrel.—The barrel is screwed into the breech piece, and to the front is fitted with the collar E, for supporting the gas cylinder. The breech piece and the barrel taken together form the gun, properly speaking, the former supporting all the longitudinal, and the latter all the tangential strain.

Gas cylinder.—The gas cylinder is supported at the front by the collar E, and at the rear by the receiver; it is in communication with the barrel by means of the gas port.

Regulator.—The regulator R is mounted in front of the gas cylinder, and may be screwed in and out, varying the amount of gas admitted to the cylinder, and consequently the power for working the mechanism.

THE MECHANISM.

Piston.—The piston comprises the body F, and the head F^1 .

Body.—The front of the body f is formed to receive the pressure of the powder gas, and on its upper surface, which is flattened, are formed the large and small feeding cams. On the right is worked the guide groove of the ejector, and to the rear, and below, is mounted the sear K. The piston body is hollow for the greater portion of its length, to receive and house the mainspring G.

Head.—The head is bored longitudinally to receive the breechblock N, and slotted for the passage of the lower extractor at F^2 . Near the front face are formed the extractor cams o , o .

Cocking handle.—The cocking handle J is mounted in grooves in the lower part of the receiver, and when drawn to the rear abuts against a projection on the piston, permitting the latter to be pulled to the rear and the gun cocked. During firing the cocking handle is held to the front by a spring clip, and does not participate in the movements of the mechanism.

Breechblock.—The breechblock is essentially cylindrical in form, and is hollowed to receive the firing pin Q. To the front are formed the two locking lugs N^1 , N^1 , which, bearing against the surfaces B^2 , B^2 , in the breech piece, support the stress of recoil. At n^2 is formed an annular groove, in which are engaged the extractor hooks O^2 . An abutment n^3 is formed to the front, and to the rear the two opening lugs n , n . In the body of the breechblock are cut two spiral slots P, P, terminated to the front and rear by short portions parallel to the axis.

Firing pin.—The firing pin Q is mounted in the breechblock, and is forged in a single piece. It is provided with an eye for the passage of the assembling pin.

Assembling pin.—The breechblock and piston are connected by means of the assembling pin M, which passes through the piston head, the firing pin, and the spiral slots of the breechblock.

Ejector.—The ejector is seated in a recess in the right side of the receiver. Its lower portion is shaped to partially embrace the body of the piston, and in this part is formed a stud which engages with the guide groove of the piston. The head of the ejector is shaped to the profile of the cartridge case.

Firing gear.—The firing gear is mounted on the left side of the receiver and protected by the breech cover. It comprises the firing lever Y, the trigger X, the trigger spring X^2 , and the controlling lever Z. The trigger comprises the trigger proper x^1 and its shaft, the spring lever x^2 , and the firing toe x^3 . The trigger spring is in tension between the spring lever x^2 and the arm y^2 of the firing lever; it tends to turn the trigger upward until the firing toe x^3 rests against the stop a on the receiver.

The firing lever Y is mounted on the pivot a^1 , and moves between the receiver and the left cheek of the breech cover. The journal y^3 is oveled two diameters.

The controlling lever is prolonged to the left to form the hand rest z . The gunner grasps this at the same time as the firing handle y^1 , and by bringing the two together fires the gun. On the shaft z is formed the controlling stop Z, on which are formed the lug z^1 and the recess z^2 . By turning the lever z^4 either one of the parts z^1 , z^2 , z^3 may be brought into the path of the firing lever Y.

Action of firing gear.—Suppose it be desired to lock the gun against accidental discharge. The controlling lever z^4 is turned to the position marked "safety." In this position the lug z^1 is brought into the path of the firing lever, and the latter can not be moved to the rear sufficiently to free the trigger from the sear. Suppose it be desired to fire single shots. The controlling lever is turned to the position marked "single shots." In this position the recess z^2 is in the path of the firing lever, and the latter may be brought to its extreme rearward position. As the firing lever is brought to the rear, the firing arm y^4 bears on the firing toe x^3 and causes the trigger to turn until the sear is released. The firing arm now rides over the firing toe, and the trigger resumes its original position. In order to fire a second shot it is necessary to release the firing lever, when the firing arm y^4 will spring to its first position, the oveled journal y^3 permitting the firing arm to ride over the end of the firing toe x^3 .

For automatic firing the controlling lever is turned to the position marked "automatic." In this position the edge z^3 of the controlling

stop falls in the path of the firing lever and it is impossible to bring the latter sufficiently to the rear to cause the trigger to release the sear, but not far enough to enable the firing arm y^4 to spring over the firing to x^3 .

Stop.—The stop H has the double function of holding the breech-block and piston in the cocked position when the gun is not loaded, and of preventing any backward movement of the feed strip during firing. It is journaled in the right side of the receiver below the feed block, and drawn upward by the tension of the coiled spring U. It may be freed from engagement with the piston or the feed strip by means of the handle h . On its upper end are formed two ratchet teeth, which project through a slot in the bottom of the feed block, but which are pushed downward when a feed strip is in the gun. When in the downward position, they permit tenons on the feed strip to move to the left, but prevent any movement to the right. The body of the stop is semi-circular in form, and when in its upward position falls in the path of the abutment f^2 on the piston and prevents a forward movement of the latter independently of the trigger; the feed strip is cut away to permit the stop to take this position when the last cartridge of a strip has been fired. When the strip is in the gun, the stop is held out of line with the piston, and the latter is controlled by the trigger alone.

Feed strips.—The feed strips are flat steel trays on which are formed two series of clips, which hold the cartridges near the base and the projectiles near the points, respectively. The clips are so formed that the cartridges can not be released except by withdrawing them slightly to the rear. This movement is prevented by an undulated strip of steel, the undulations of which are in line with the heads of the cartridges. As the strip is fed through the feed block these undulations are successively flattened down in the groove v^2 , and at the same time each cartridge is in turn drawn to the rear by an inclined guide. On the under surface of the strip is formed a series of tenons, which engage with the feed cams on the piston, and for each backward and forward motion of the latter cause the strip to advance the distance necessary to bring a fresh cartridge to the loading position. The feed strips are made for either 8 or 10 rounds of ammunition.

Feed belts.—The feed belts are composed of a series of independent cartridge holders, jointed together to form a chain. Each cartridge holder has four clips, two of which grasp the cartridge near its base and two the projectile near the point. A flat spring prevents the cartridge from moving longitudinally in its holder, precisely as in the case of the feed strip. The method of jointing the successive cartridge holders together is such that any holder may be removed or replaced in case of damage. The belts which are made for 25 or 50 rounds are carried coiled in service boxes, from which they are fed directly to the gun.

ACTION OF THE MECHANISM.

Suppose the gun to have been fired; as the projectile passes over the gas port c^1 a portion of the gas enters the gas cylinder D, and, striking the end of the piston f , throws the latter to the rear. As the head F^1 of the piston moves to the rear, the assembling pin M moves first along the short parallel portion of the grooves in the breechblock, withdrawing the firing pin. When the pin has been withdrawn, the assembling pin enters the spiral portion of the grooves, and as the breechblock is prevented from moving to the rear by the lugs $N^1 N^1$ bearing against the surfaces $B^2 B^2$ of the breech piece, the breechblock is revolved about its axis until unlocked, and until the lugs $N^1 N^1$ fall in line with the grooves $N^2 N^2$. At this moment the assembling pin has arrived at the end of the spiral portion of the grooves in the breechblock and enters the short parallel portion p . In this last movement the cams $o o$ on the head of the piston pass under the extractor levers $R^3 R^3$, and the extractors are caused to pivot about the hooks $o^2 o^2$, forcing the claws into positive engagement with the empty cartridge. At this moment the rear face P^3 of the piston head strikes the opening lugs $n n$, and the breechblock moves to the rear with the piston. The ejector stud, during the first part of the movement of the piston, is engaged in a portion of the ejector guide which is parallel to the direction of the movement. When, however, the breechblock has arrived sufficiently to the rear to unmask the ejection opening, the stud enters the inclined part of the guide groove and causes the ejector to revolve about the piston, striking the empty cartridge and forcing it out of the ejection opening. Here it is received by the deflector and caused to fall vertically to the ground. As the piston continues to recoil, compressing the main spring, the small feed cam engages behind one of the tenons of the feed strip and partially advances the latter to the loading position. Finally, when the piston has finished its movement to the rear, the sear K engages with the trigger x^1 , and the gun is cocked ready for the next shot.

On pulling the trigger the piston is thrown to the front by the mainspring, and in its forward movement the large feed cam strikes the tenon of the feed strip, and brings the cartridge fully to the loading position. As the piston starts forward, the assembling pin moves along the parallel portion of the grooves in the breechblock, and the cams $o o$ pass from under the ends of the extractor levers and free the extractors. As the piston continues to advance, the assembling pin M enters the spiral portion of the grooves, and as the breechblock is prevented from turning through the lugs $N^1 N^1$ being engaged in their guides, the breechblock moves forward with the piston. The projection o^3 on the lower extractor strikes the cartridge, pushes it home in the chamber, and the extractor claws pass over the flange of the car-

tridge. The breechblock is now stopped by its front face n^3 striking the rear of the breech piece, the locking lugs in line with their seat b^1 . The piston continuing its forward movement, the assembling pin moves along the spiral portion of the grooves and causes the breechblock to make a half turn and lock, the lugs bearing to the rear against the abutments B^2 B^2 of the breech piece. The breech being now fully closed, the assembling pin passes into the parallel portion of the grooves, forces the firing pin against the primer, and fires the gun. The piston is stopped by the abutment P^1 striking the corresponding abutment P^2 on the breechblock.

In order to fire the first round, it is necessary to cock the gun by hand by means of the cocking handle J, but after this the action of the gun is completely automatic, as the stop, as already explained, holds the breech open after the last round on each feed strip has been fired.

DISMOUNTING AND ASSEMBLING THE MECHANISM.

The mechanism is dismantled and assembled without the use of tools, as follows: The breech being closed, remove the breech-cover pin, turn back the breech cover on the receiver, unhook both ends of the trigger spring, remove the firing lever and the trigger, pull out the controlling lever and withdraw its shaft, withdraw the mainspring, remove the piston and with it the breechblock, back out the assembling pin, give a quarter turn to the breechblock and dismount from piston, drop out firing pin, unhook extractors, remove ejector, unhook stop spring, and remove stop.

The mechanism is assembled in inverse order.

CARE AND PRESERVATION.

The gun requires no special care beyond being kept clean, free from dust, and undefaced. No brick dust or gritty substances should be used on any part of the mechanism, nor should the parts be scraped with knives or roughened in any way.

All parts of the gun should be kept well oiled as a protection from rust.

Always, after firing, the gun should be thoroughly cleaned. To do this, dismount the mechanism completely and wash every part thoroughly with warm fresh-water soapsuds. Mechanism, barrel, and cylinder should be treated alike. Stains and residue of the powder can be best removed with petroleum. Special care should be taken to remove all residue from the gas cylinder.

After cleaning, all parts should be thoroughly dried, and then well oiled with light machine oil or vaseline.

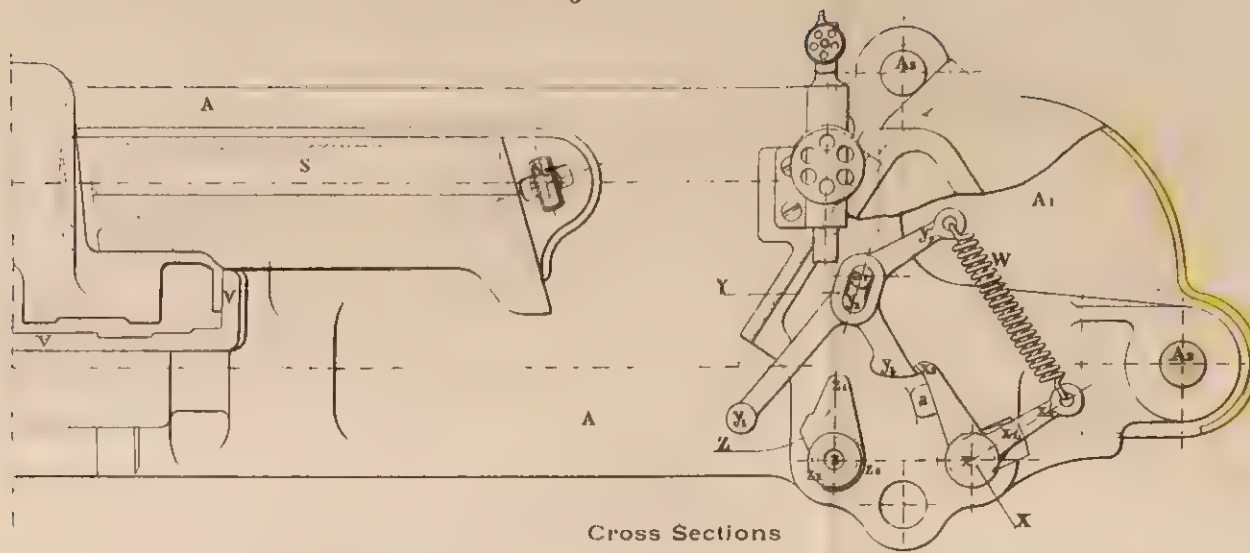
Inspect and reoil once a week. In reoiling, remove all of the old oil that has become clogged with dust or grit.

After firing or cleaning close the breech; never leave the gun at full cock.

HOTCHKISS 1-PDR AUTOMATIC MACHINE GUN.

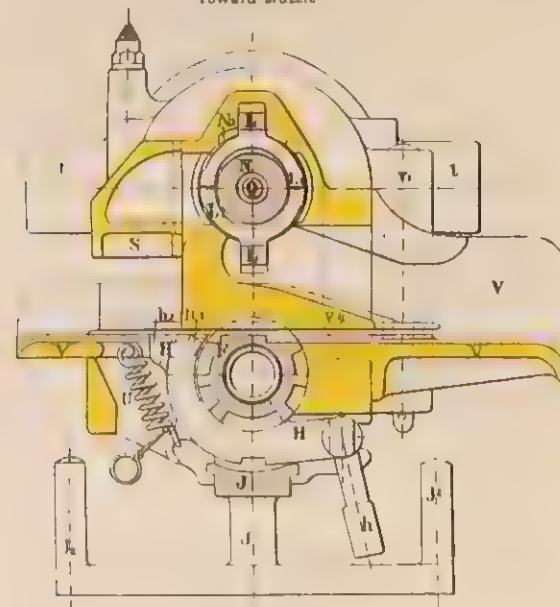
Pl. I.

Detail of Firing Gear.

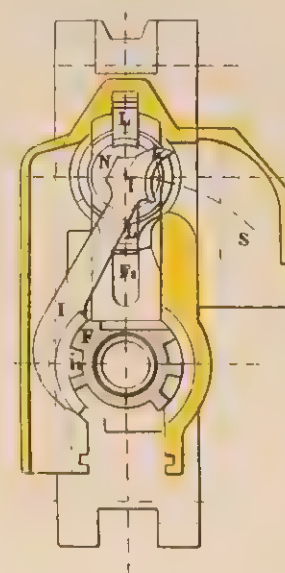


Cross Sections

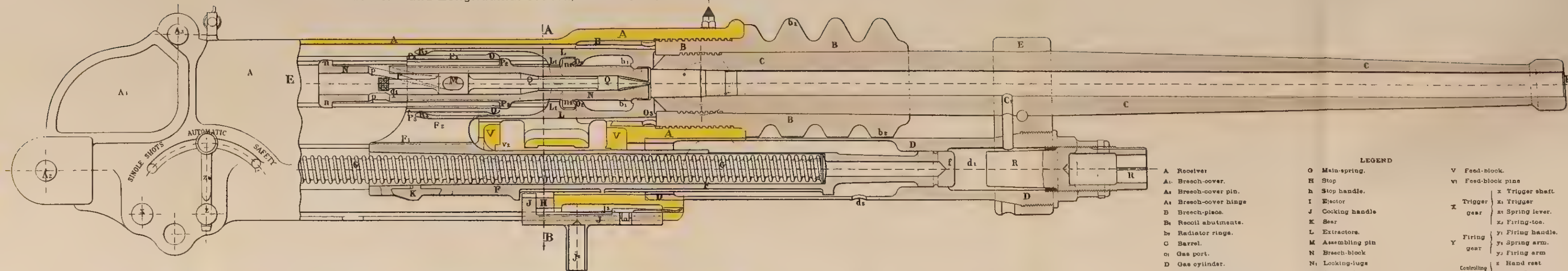
On Line A. B.
Toward Muzzle



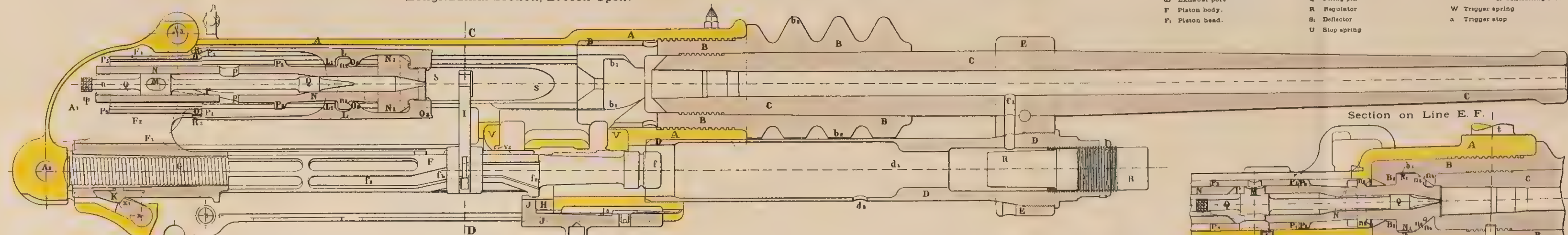
On Line C. D.
Toward Breech



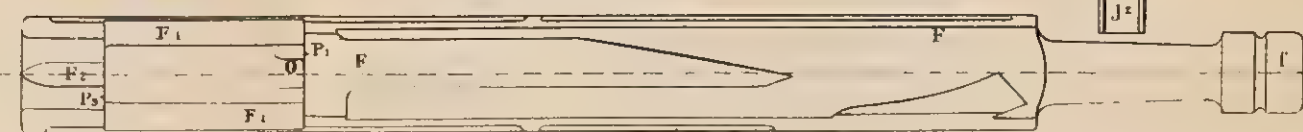
Side View and Longitudinal Section, Breech Closed.



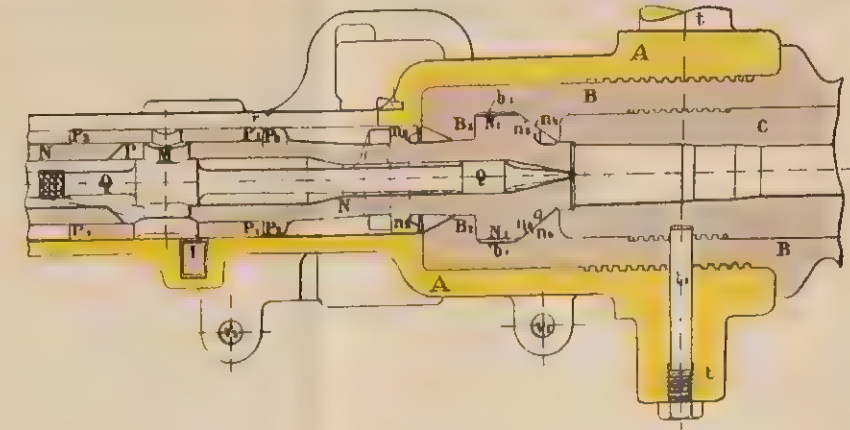
Longitudinal Section, Breech Open.



Plan of Piston.



Section on Line E. F.



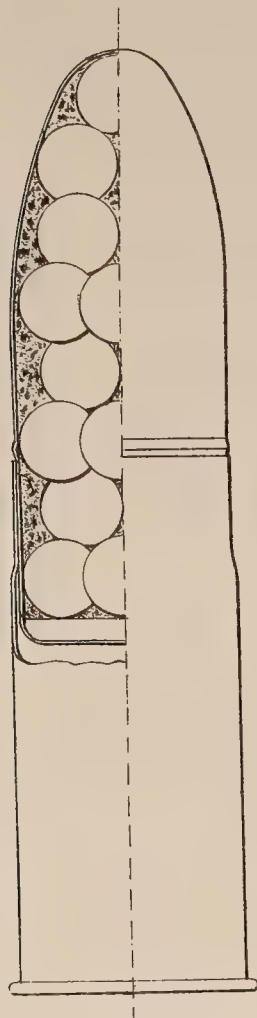
- | | | |
|------------------------------------|------------------------------|-------------------------------------|
| A Receiver. | O Main-spring. | V Feed-block. |
| A ₁ Breech-cover. | H Stop. | v ₁ Feed-block pins. |
| A ₂ Breech-cover pin. | h Stop handle. | x Trigger shaft. |
| A ₃ Breech-cover hinge. | I Ejector. | x ₁ Trigger lever. |
| B Breech-piece. | J Cocking handle. | x ₂ Spring lever. |
| B ₁ Recoil abutments. | K Sear. | x ₃ Firing-ton. |
| b ₁ Radiator rings. | L Extractors. | y ₁ Firing handle. |
| C Barrel. | M Assembling pin. | y ₂ Spring arm. |
| c ₁ Gas port. | N Breech-block. | y ₃ Firing arm. |
| D Gas cylinder. | N ₁ Locking-lugs. | z Hand rest. |
| d ₁ Expansion chamber. | n Opening-lugs. | z ₁ z ₂ Lugs. |
| d ₂ Exhaust port. | Q Firing-pin. | z ₃ Controlling lever. |
| F Piston body. | R Regulator. | W Trigger spring. |
| F ₁ Piston head. | S Deflector. | a Trigger stop. |
| | U Stop spring. | |



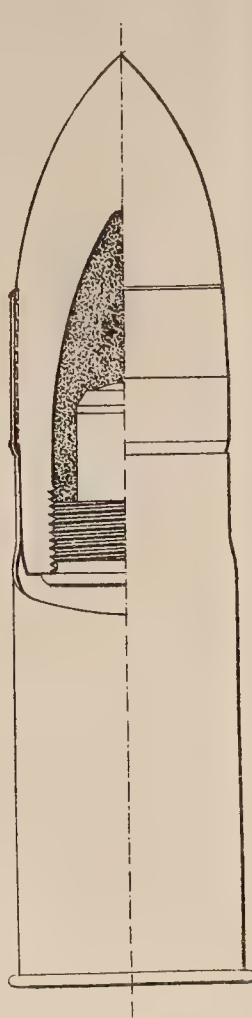
HOTCHKISS 1-PDR AUTOMATIC MACHINE GUN .

AMMUNITION.

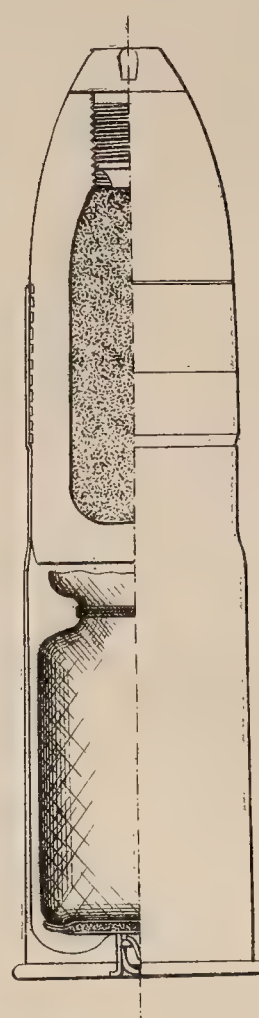
Cartridge with canister.



Cartridge with steel shell.

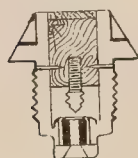


Cartridge with common shell.



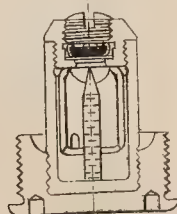
Desmarest Fuze.

Naval Service.

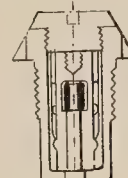


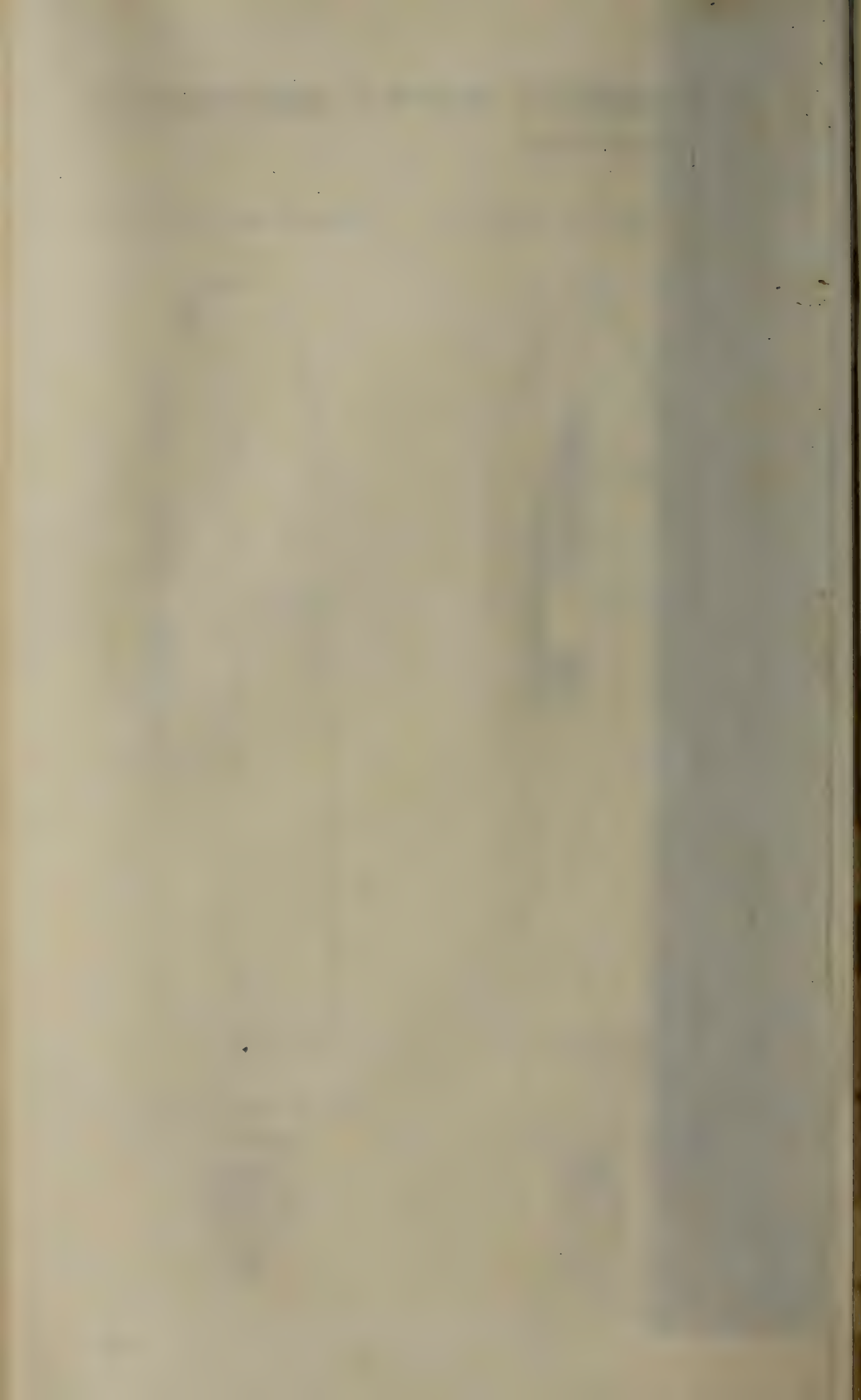
Hotchkiss Fuzes.

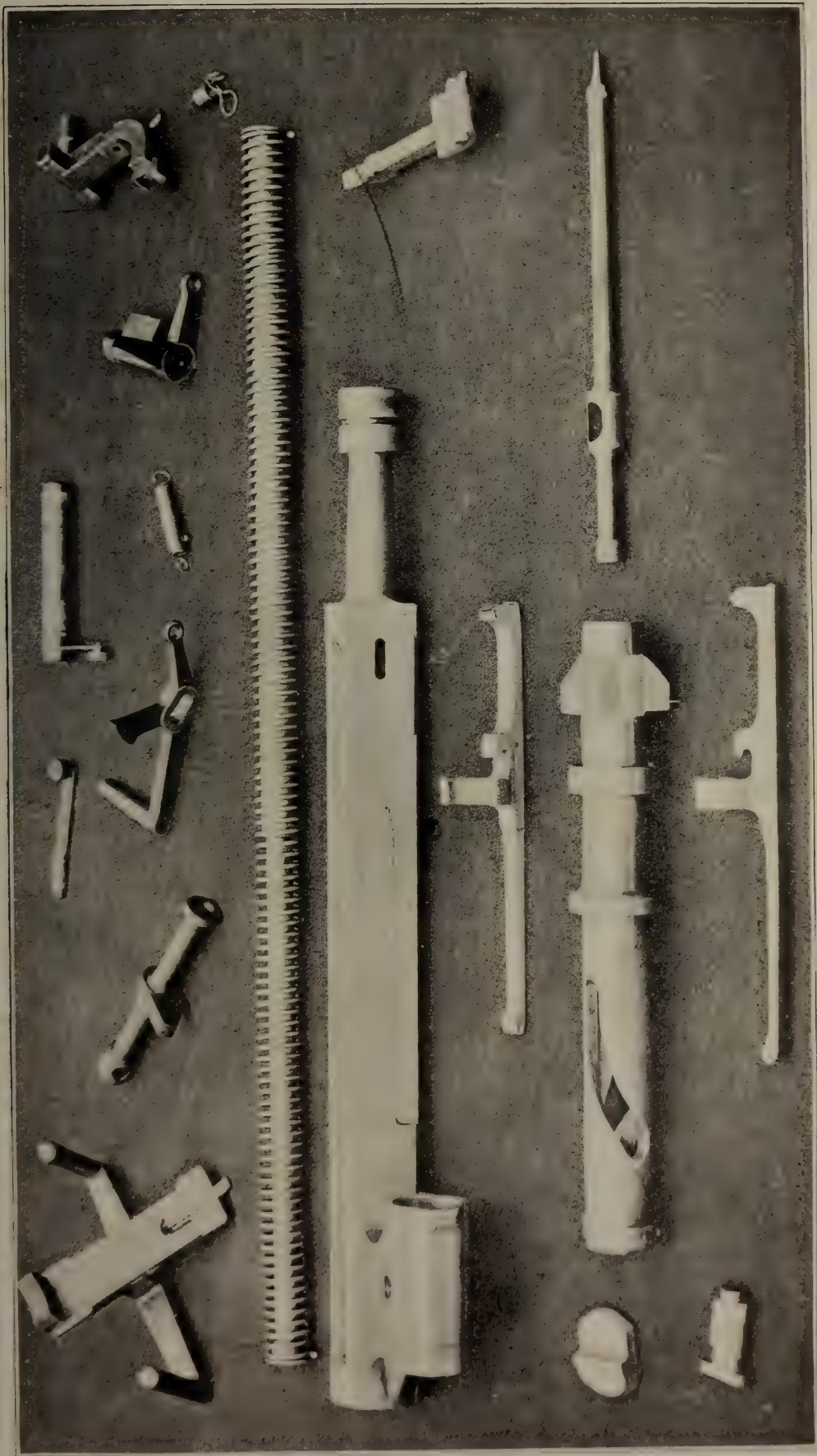
Armor piercing.



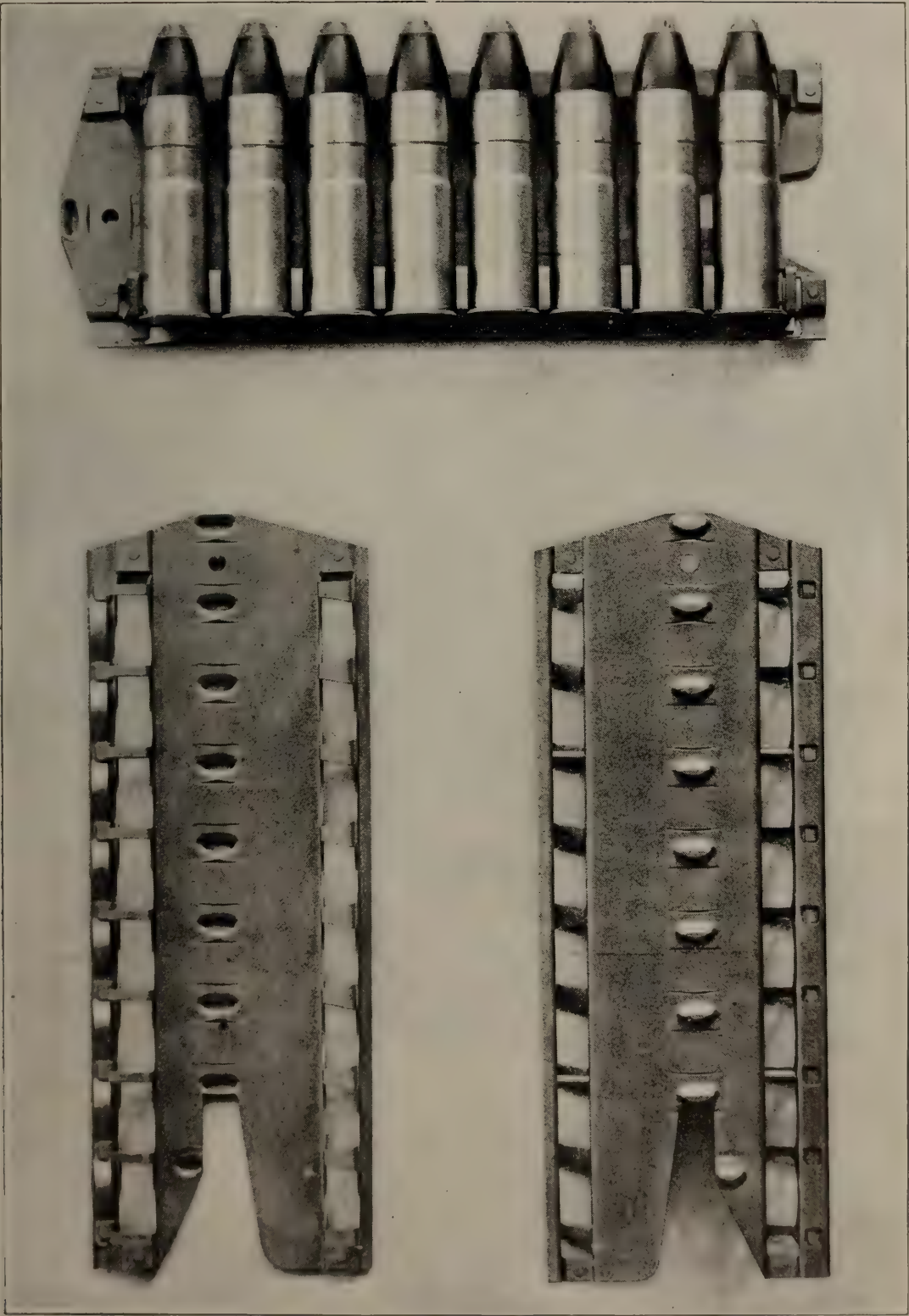
Land Service.



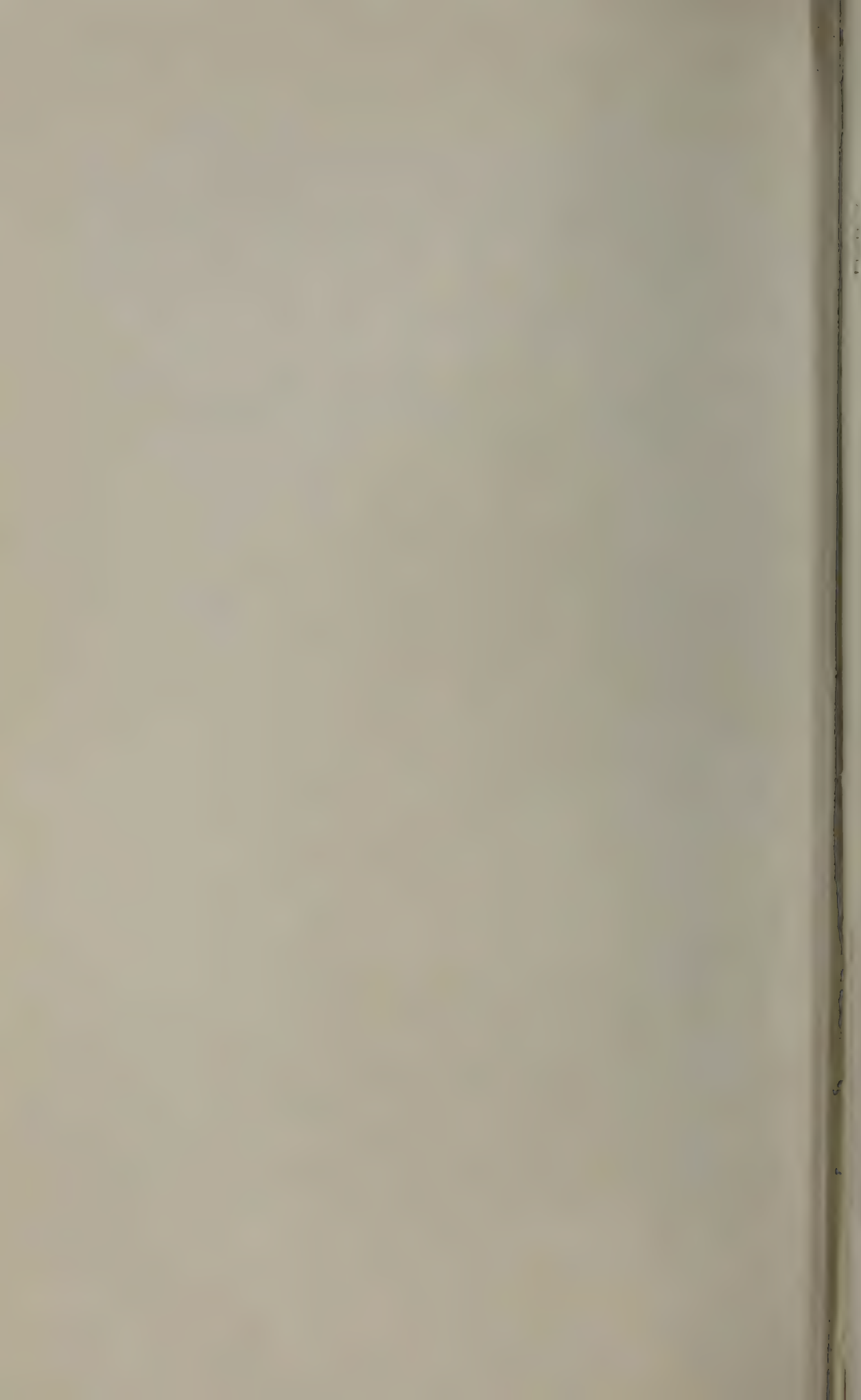


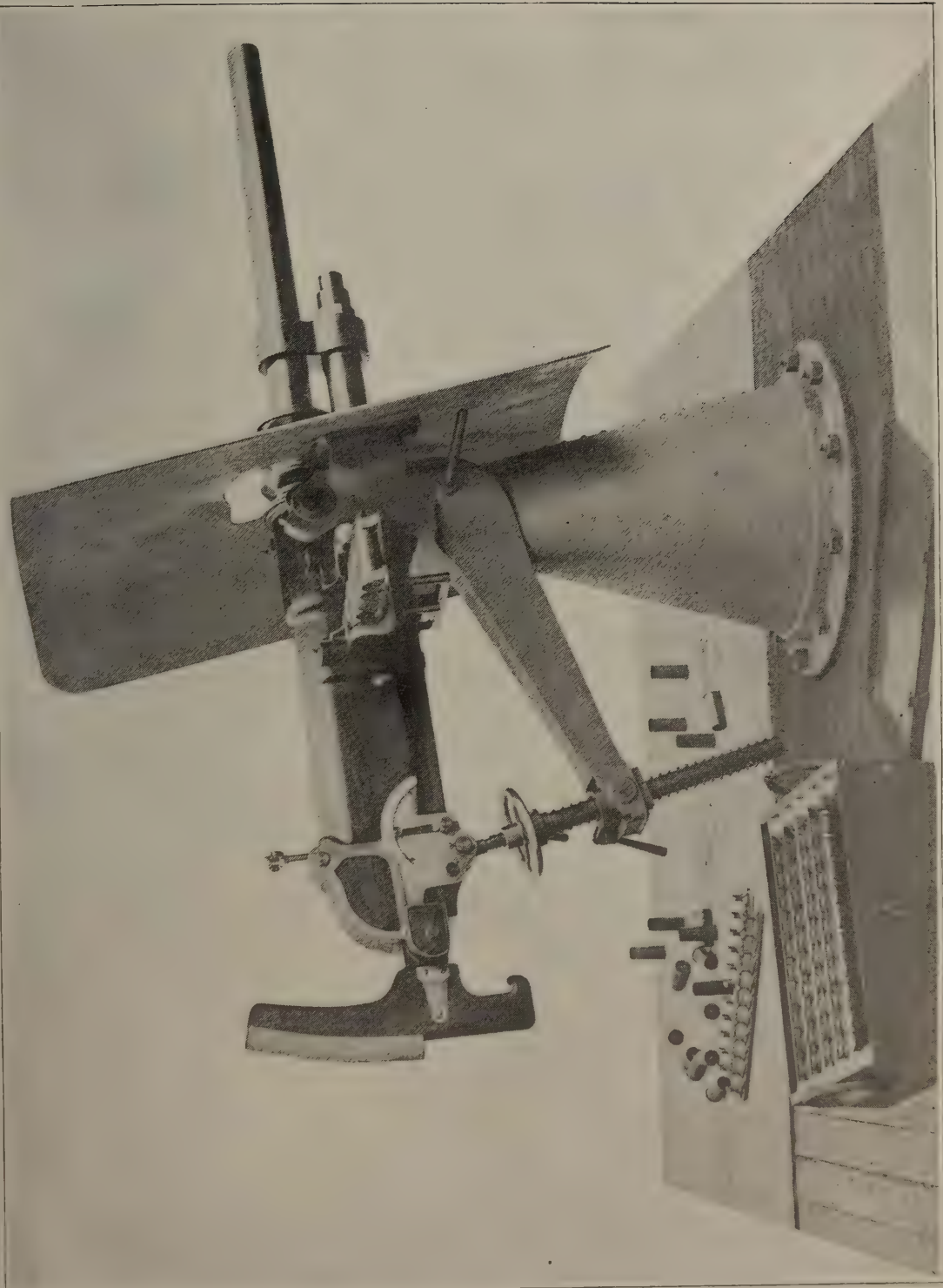


HOTCHKISS 1-POUNDER AUTOMATIC MACHINE GUN—COMPONENT PARTS OF MECHANISM.



HOTCHKISS 1-POUNDER AUTOMATIC MACHINE GUN—FEED STRIP WITH CARTRIDGES.





HOTCHKISS 1-POUNDER AUTOMATIC MACHINE GUN—DECK MOUNTING.



HOTCHKISS 1-POUNDER AUTOMATIC MACHINE GUN—FIELD CARRIAGE.



HOTCHKISS 1-POUNDER AUTOMATIC MACHINE GUN—FIELD LIMBER.

If any difficulty occurs in loading, cock the gun and load with a fresh feed strip.

If the gun does not extract, screw in the regulator a few turns. This will increase the pressure and probably remedy the difficulty. If this is not sufficient, change one or both of the extractors.

Although the following parts are required for the perfect working of the gun, they are not absolutely essential, and any one or all of them may be broken or removed without disabling the gun. Thus the gun will fire automatically without the stop, stop-spring, trigger, sear, trigger-spring, controlling lever, controlling-lever shaft, and deflector.

The powder charges are normally 40 grams of French smokeless powder with an ignitor of 2 grams. Black powder is not employed in the automatic gun because of the smoke and residue, the latter clogging the gun.

Deck mounting.—This mounting is arranged to embody the feature of quick pointing directly from the shoulder, together with elevating gear, which may be employed when required. The gun is mounted on a gun-metal pivot, on which are formed lugs for carrying a bullet-proof shield. A bracket is formed on the rear of the pivot for supporting the elevating gear. The pedestal is a light steel cone in which are riveted the gun-metal socket and the holding-down ring. The elevating gear comprises a hollow rod, on which is formed a series of interrupted annular ribs, and which engages with a nut journaled in the bracket of the pivot. This nut can be given a quarter turn by means of a self-locking lever placed conveniently to the gunner's hand. When the lever is turned to the left, the nut engages with the annular ribs on the rod, and the gun is locked in elevation. In this position the gun may be elevated or depressed through a range of 10 degrees by means of a handwheel and elevating screw mounted in the rod itself. When the lever is turned to the right, the ribs on the rod register with blanks in the nut, and the gun is free to be pointed in elevation by means of the shoulder piece. The gun is trained directly from the shoulder and may be instantly clamped in any desired direction.

Weights and measurements.

Gun:

Diameter of bore.....	millimeters..	37
Length of bore (35 calibers)	do....	1, 295
Total length of gun	do....	2, 213
Weight of gun complete.....	kilograms..	170

Ammunition:

Weight of charge	grams..	40
Weight of projectile	do....	450
Weight of complete cartridge	do....	650
Initial velocity	meter-seconds..	500

Feed strips:

Weight of feed strip with 10 rounds	kilograms..	7.5
Weight of feed strip with 8 rounds	do.....	6.5
Weight of feed belt with 25 rounds.....	do.....	23.0

Deck mounting:

Weight of mounting without shield.....	do.....	205
Weight of 6-millimeter shield.....	do.....	60
Height of axis of gun above platform.....	millimeters..	1,120
Maximum angles of fire.....	degrees.....	{ - 15 - 20
Weight of gun, mounting, and shield.....	kilograms..	435

Field carriage:

Total weight of gun carriage	do.....	265
Weight of one wheel	do.....	45
Diameter of wheels	millimeters..	1,150
Track of carriage.....	do.....	1,200
Height of trunnions above ground.....	do.....	950
Maximum angle of elevation	degrees.....	- 17
Maximum angle of depression	do.....	- 14
Maximum angle of traverse.....	do.....	10
Weight of gun in battery	kilograms..	435

Limber:

Weight of limber empty	do.....	287
Number of rounds carried.....		288
Total weight of limber fully equipped	kilograms..	575

Caisson:

Weight of caisson limber empty.....	do.....	287
Weight of caisson body empty	do.....	288
Number of rounds carried by caisson.....		576
Weight of caisson fully equipped.....	kilograms..	1,100
Weight behind gun team	do.....	1,010

KRUPP 12-INCH AND 11-INCH GUNS FOR GERMAN SHIPS.

The 30.5-centimeter (12-inch) Krupp gun is reported as being one of the most powerful representatives of modern naval and coast guns. The tube is a little over 15 meters (49.21 feet) long and weighs nearly 64 tons. The initial velocity of the armor-piercing shell, weighing 445 kilograms (981 pounds), is 900 meters (2,952 feet), while that of the 350-kilogram (772 pounds) A. P. shell is 1,015 meters (3,358 feet). The working energy of these projectiles upon leaving the tube is 18,375 metric tons, corresponding to a penetrative power of 110 centimeters (43.3 inches) of steel, or 55 centimeters (21.65 inches) of Krupp armor, or 165 centimeters (65 inches) of wrought-iron armor.

The new German battleships J and H will have the Krupp (rapid-fire) 28-centimeter (11-inch) guns.

These new Krupp guns are claimed to have much greater muzzle velocity, 893 meters (2,929 feet) per second. This gun will weigh 38½ tons. The powder charge weighs 81.4 kilograms (180 pounds) and the projectiles 270 kilograms (594 pounds) and 345 kilograms (759 pounds). Its striking energy of 10,970 metric tons will penetrate 83.6 centime-

ters (32 inches) of steel. It is reported that a 17-centimeter (6.7-inch) R. F. gun will be introduced, thus giving the German navy 8 calibers of rapid-firing guns, viz: 28-centimeter (11-inch), 24-centimeter (9.25-inch), 21-centimeter (8.27-inch), 17-centimeter (6.7-inch), 15-centimeter (5.9-inch), 10.5-centimeter (4.13-inch), 8.8-centimeter (3.47-inch), and 5-centimeter (2-inch) guns.

DISMOUNTING CONSTRUCTION FOR MACHINE GUNS.

This construction is applicable to automatic machine guns having a sliding barrel and a water jacket, as in the well-known Maxim 37-millimeter gun, the chief object of the design being to so construct these guns that the barrel and its water jacket can be readily and simultaneously detached for convenience in transporting the gun. For this purpose the breech end of the barrel is formed with lateral fins or projections to engage with corresponding grooves or recesses in the recoiling plates or frame; also the breech end of the water jacket is formed with dovetail or similar grooves for the reception of correspondingly shaped ribs or projections on the breech casing. The grooves or recesses in the recoiling frame and the dovetail grooves in the breech end of the water jacket are preferably disposed vertically so as to permit of the parts fitting together by a vertical movement.

For facilitating the detachment of the parts, a releasing tool or lever, as hereinafter explained, is employed.

Fig. 1 is a side elevation, and fig. 2 a plan of a Maxim gun provided with this improvement, the detachable water jacket and barrel being represented in these figures detached from the breech casing. Fig. 3 is a side elevation of the gun with a portion broken away to show the parts connected. In this view is represented the tool or lever in position for facilitating the detachment of the parts and with such detachment partly effected.

A A are the side plates of the breech casing and B B the recoiling plates or frame. C is the barrel and D the water jacket.

c c are the lateral fins or projections on the barrel near the breech end thereof, and *b b* are the corresponding recesses or vertical grooves in the recoiling plates B, with which said fins or projections are adapted to engage. The metal at the entrance to these recesses or grooves is chamfered or "faced off," as shown in fig. 2, and the lower ends of the projections *c* are curved or rounded (fig. 1) so as to facilitate the engagement of the said projections with the said grooves. *d d* are the vertical dovetailed recesses or grooves in the water jacket and *a a* the corresponding ribs or projections on the breech casing with which they are adapted to engage. The dovetailed ribs *a* are located on the inner surface of the side plates A of the breech casing, and preferably consist of tapered strips riveted or otherwise securely attached to said side plates. At or near the bottom of the side plates, stops *a'* may be

provided for preventing the water jacket and its barrel from descending too far when being connected with the breech casing.

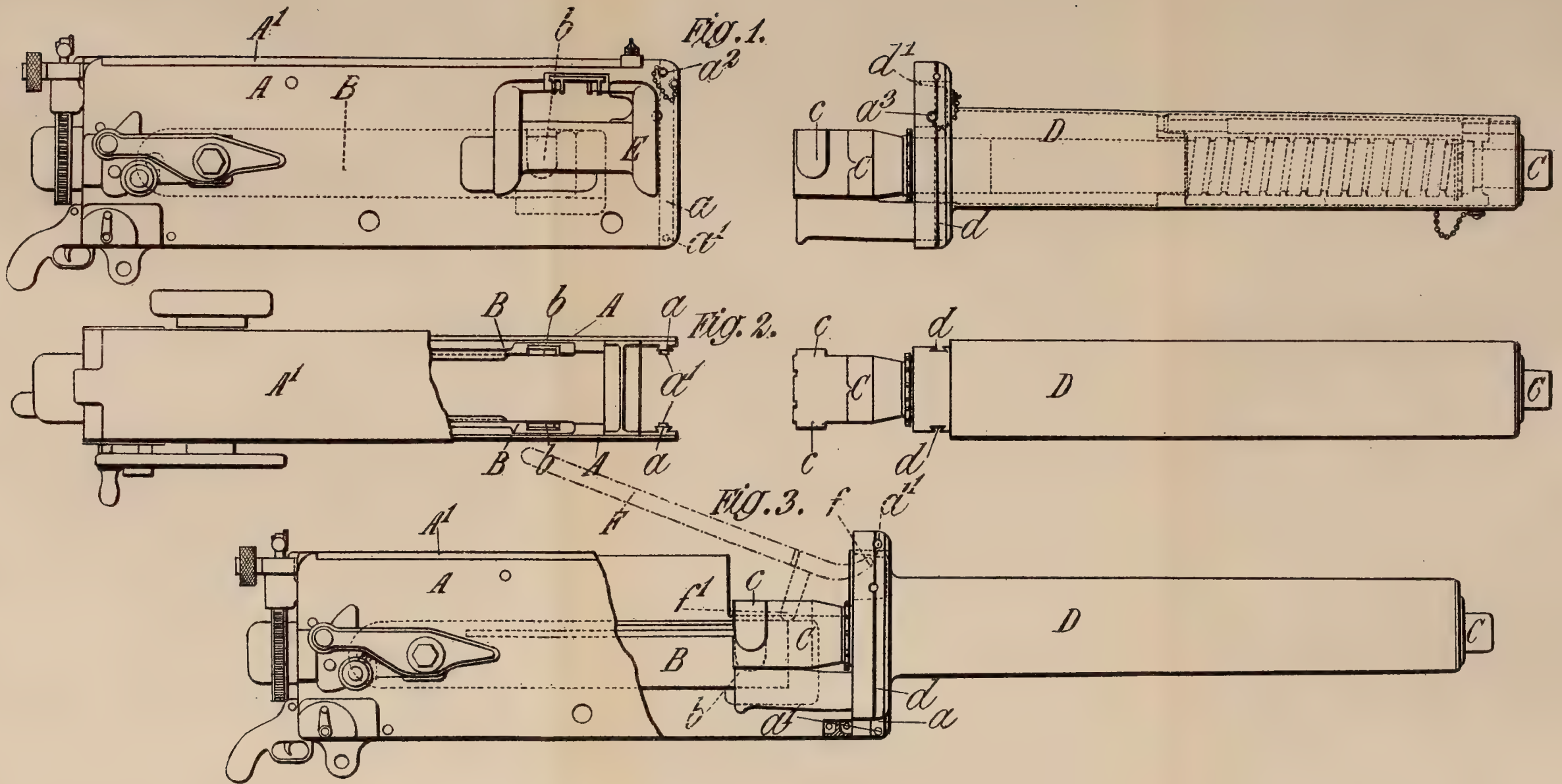
In order to connect the parts it is necessary to first detach the hinged cover A^1 of the breech casing by the removal of its hinge pin a^2 and also to remove the feed block E and the lock. The water jacket with its barrel is then placed in such position relatively to the breech casing that the dovetail strips a on the casing and the grooves b in the recoiling frame coincide with the dovetail recesses d in the water jacket and the lateral fins or projection c on the barrel. The water jacket and barrel are then pressed downwardly with respect to the breech casing, and the upper portion of the barrel is given a slight blow to cause the parts to become firmly connected together, the stops a^1 limiting the extent of movement of the water jacket and barrel in this operation. A transverse pin a^3 is inserted to retain the connected parts together, and the cover, feed block, and lock are then replaced. The gun is then ready to be mounted on its tripod or support for firing.

F is the tool or lever which may be employed for facilitating the detachment of the barrel and water jacket from the breech casing and which is represented by dotted lines in fig. 3. This tool or lever is constructed with a bent or curved part f to engage with the rear portion d^1 of the water jacket, and it is also formed with a forked heel f^1 to bear upon the upper portion of each of the recoiling plates or other convenient part of the breech casing, said forked heel serving as a fulcrum for the lever to turn about in starting the upward movement of the water jacket and barrel with respect to the breech casing. The parts having thus been initially liberated from engagement with one another, their complete detachment can readily be effected by the operator's hands without further use of the aforesaid tool.

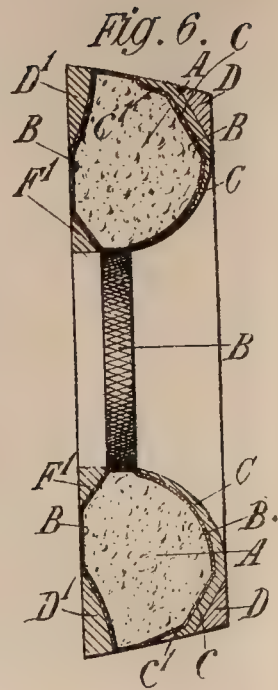
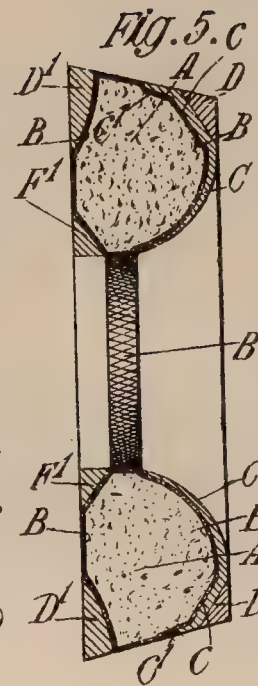
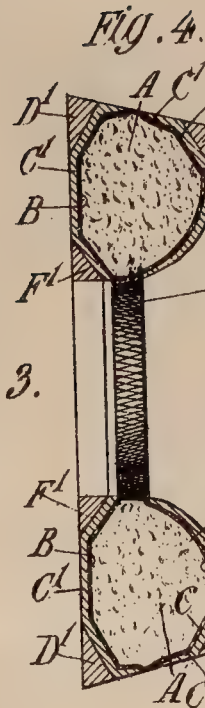
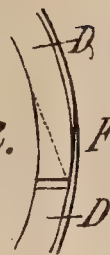
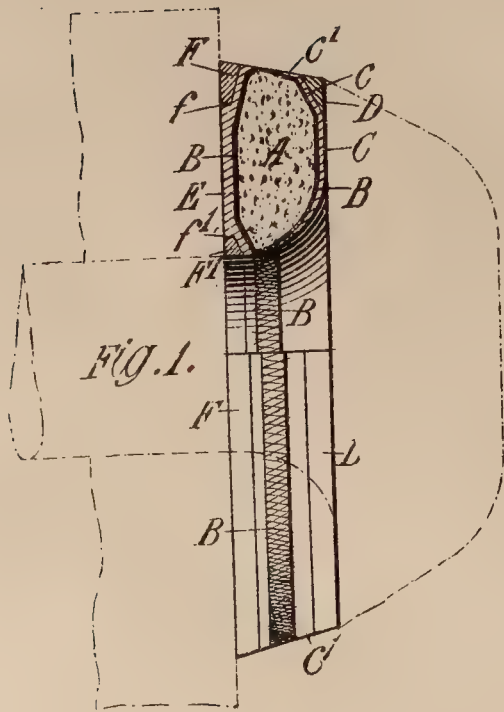
IMPROVEMENT IN OBTURATORS OF THE DE BANGE TYPE.

This improvement relates to obturators of the "De Bange" type for breech-loading ordnance and aims to improve the construction of such obturators so that the liability of their pads to injury during use will be much less than heretofore.

For a gun having a swinging, screw-threaded breech block, with interrupted threads, the outer circumference or seat of the obturator pad (that is to say the part which fits radially against the breech chamber) is made conical or ogival in form, so that in the swinging of the block in opening or closing the breech the obturator will easily leave or enter its place within the breech chamber without requiring to be shifted rectilinearly. The said pad preferably consists of a composition of asbestos and mutton suet, covered with canvas, and is made in the form of a ring in the manner usual with the "De Bange" obturators.



DISMOUNTING CONSTRUCTION FOR MACHINE GUN.



MODIFICATION OF DE BANGE OBTURATOR.

In such obturators experience has proved that during use the canvas of the pad is liable to injury, particularly at the forward circumferential part at the junction between the said canvas and the edge of the disks employed for protecting the pad. It is the chief object of this improvement to overcome this liability to injury by providing the pad with a protecting metallic cup or cups and a split ring or rings as hereinafter explained.

Figure 1 is a sectional side view of one form of obturator. Fig. 2 is a transverse section of the split ring used with this form of obturator. Fig. 3 is a detail face view of a portion of the said ring (looking toward the left of Fig. 2) and showing how its ends overlap. Figs. 4, 5, and 6 are sections of modified constructions of the obturator.

Like letters of reference indicate similar parts in all the figures.

Referring more particularly to Figs. 1 to 3, A is the body portion or pad of the obturator and B the canvas covering thereof. The front portion of the pad is provided with a protective facing or cup C of copper or other appropriate material interposed between the mushroom head of the obturator bolt (shown in dotted lines) and the forward part of the pad, said forward part being preferably beveled at *c* near its periphery. The said copper facing or cup is also preferably flanged rearwardly to form a circular lip *c*¹, which will cover a part of the pad that would otherwise be exposed at the periphery. This rearwardly flanged portion may taper to a thin or knife edge. At the front beveled part *c* of the periphery of the copper facing or cup is provided a steel or other suitable split ring D which is preferably of triangular cross section to fit the correspondingly beveled portion of the copper facing or cup C, but which is not connected to the latter. The rear portion of the pad may be protected with a tin or other suitable metal disk E and steel ring F F' in the usual manner with "De Bange" obturators, these rings being secured in place by the dovetailed portion of the said metal disk E, which fits the annular dovetail groove formed by the inclined inner edges *f* *f*¹ of the rings.

With this construction of obturator, when the gun is fired the gaseous pressure generated therein causes the mushroom head of the obturator bolt to exert great pressure on the pad, as is well understood, thereby compressing the latter and causing the copper facing or cup C and the steel split ring D to make a tight joint at the periphery of the obturator, and to thus effectually seal the breech opening of the gun. The action of the rear disk is practically the same as in the ordinary form of the "De Bange" obturator.

The special advantage of the copper facing or cup C is that, if the obturator does not truly fit the gun, the compression of the pad causes the said facing or cup to take a permanent "set" against the said seat, thus permanently compensating for any inequality of the fit.

The front split ring D insures a metallic contact with the periphery

of the obturator, so that when rapid firing is effected the great heat resulting therefrom is conducted from the mushroom head of the gun by reason of the said metallic contact.

The powder gases are prevented from attacking the pad at the point where the steel ring D is split by the pressure of the mushroom head against the copper facing or cup C. The facing or cup should be made of such thickness as to prevent injury to the obturator by successive intermittent pressures occasioned by rapid firing.

Fig. 4 shows the pad A provided with a copper or other appropriate metal protective backing or cup C¹ at its rear in addition to the front facing or cup C, and also with a rear split ring D¹ in addition to the front split ring D. In this case the rear rings D¹ and F¹ are not formed with the dovetail portions represented in Fig. 1, and the holding of the rings in place is dependent upon the obturator bolt and breechblock retaining the pad between them.

In Figs. 5 and 6 the metal disk E and the rear cup C¹ shown in the preceding figures is dispensed with, but in other respects the obturator is similar to those already described, except that in Fig. 6 it is of curved or ogival form on its periphery, the curve being struck from the axis of the hinge about which the breechblock swings.

The rear metallic cup C¹ and split ring D¹ (fig. 4) may be used without the forward cup C and split ring D if desired, and in some cases the rear slit ring D¹ without the rear metallic cup C¹, or the rear split ring D¹ may be used with both the forward metallic cup C and the split ring D, or either of them.

KRUPP BALL BEARINGS FOR TURRETS.

The use of ball bearings for turrets has been found by Krupp to give many advantages. For turrets weighing 200 tons, balls of 80 to 90 millimeters (3.15 to 3.4 inches) in diameter are used. For turrets weighing 300 tons the diameter is increased to 120 millimeters (4.72 inches).

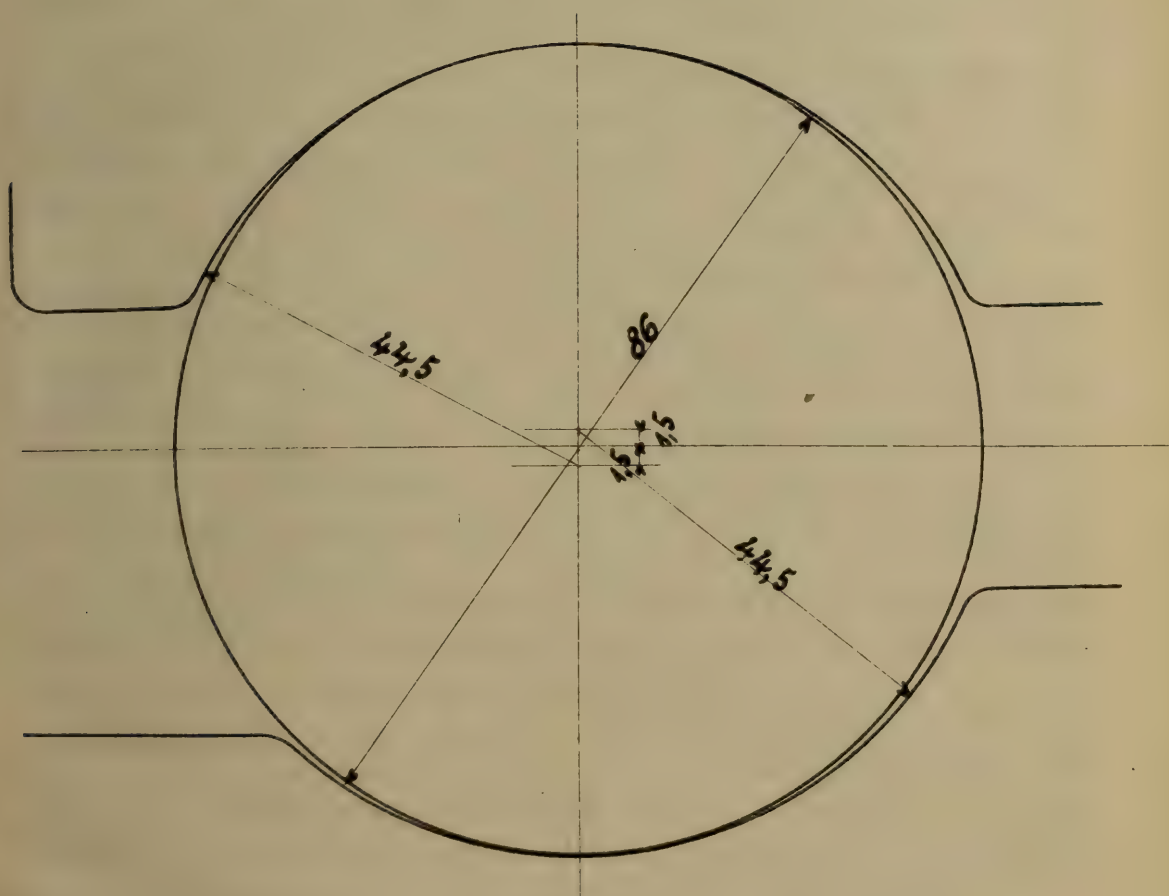
The weight carried by a ball of 80 to 90 millimeters is from 2,204 to 3,396 pounds, while that sustained by the 120-millimeter balls is 5,512 pounds. The ball track shown in section in the sketch is 15.74 feet in diameter and contains 152 balls of a diameter of 86 millimeters.

A guide rail is used to retain the balls in position.

ELECTRO-HYDRAULIC TRAINING GEAR FOR GUN PLATFORMS.

This training apparatus provides for the use of electrical driving gear adapted to obtain the extremely slow and slight movements which are obtainable with hydraulic appliances in the training of revolving platforms when the same are out of balance or working in a sea way.

The apparatus consists of the combination with an ordinary shunt-wound motor running at constant speed, of a hydraulic apparatus so



Krupp Ball Bearings for Turrets.



[Faint, illegible text, possibly a title or description.]

arranged that whilst the electrical motor runs constantly at a uniform speed and in a continuous direction, the speed and direction of movement of the hydraulic apparatus, and consequently that of the platform, can be varied at will. For this purpose the hydraulic motor is provided with a special valve between the pump and motor. The said valve is arranged to control the passage of liquid from the pump to the motor, so that although the pump is driven at a constant speed by the electric motor, the speed of the hydraulic motor can be varied as desired and the latter can be run in either direction at will. When operating the platform at full speed all the liquid delivered by the pump will pass to the hydraulic apparatus, but if only half full speed is required, only half the liquid will pass to the pump, and so on in proportion. The remaining portion of the liquid returns through a by-pass orifice to the pump, the said orifice being so formed and arranged that the full pressure required to operate the platform will always be maintained between the pump and the motor. A tank or reservoir of liquid is preferably located between and communicates with the pump and motor. When the controlling valve is in a central position all the water will be discharged through the by-pass and no motion can be communicated to the platform, but when the valve is moved from this central position motion will be given to the apparatus in a direction depending upon the direction in which the valve has been moved and the platform will be trained in the corresponding direction. The valve is arranged to be operated by any convenient means from the sighting stations or other suitable position.

A is the revolving gun platform. B is the electromotor. C is the shaft carrying the training pinion D. E is the toothed ring with which said pinion gears and around which it travels to revolve the platform, as is well understood. F is a cranked shaft for enabling the said training pinion to be revolved by hand when required.

Referring to figs. 1 and 2, G is the hydraulic pump which is actuated by the electromotor B through bevel gearing $b^1 b^2$ and a shaft b , whereby said pump is worked at a uniform speed continuously in the same direction. This pump is connected by a pipe g to a liquid reservoir or tank H and is also connected by a pipe g^1 to the casing I of the controlling valve i , which casing is in turn connected by pipes h^1 and h^2 to the hydraulic motor J and by a pipe h to the said tank. The valve i is by suitable mechanism capable of being worked from the sighting stations or other appropriate place, and can be set into a position to permit liquid under pressure to be supplied by said pump through the pipes $g^1 h^1$ to the motor J, whence said liquid returns by pipes h^2 and h to the tank H; or, the said valve can be set into a central position to permit the liquid from the pump to pass back to the tank through the pipe h without operating the motor. The driving shaft of the motor J is furnished with a toothed pinion j gearing with a toothed wheel j^1

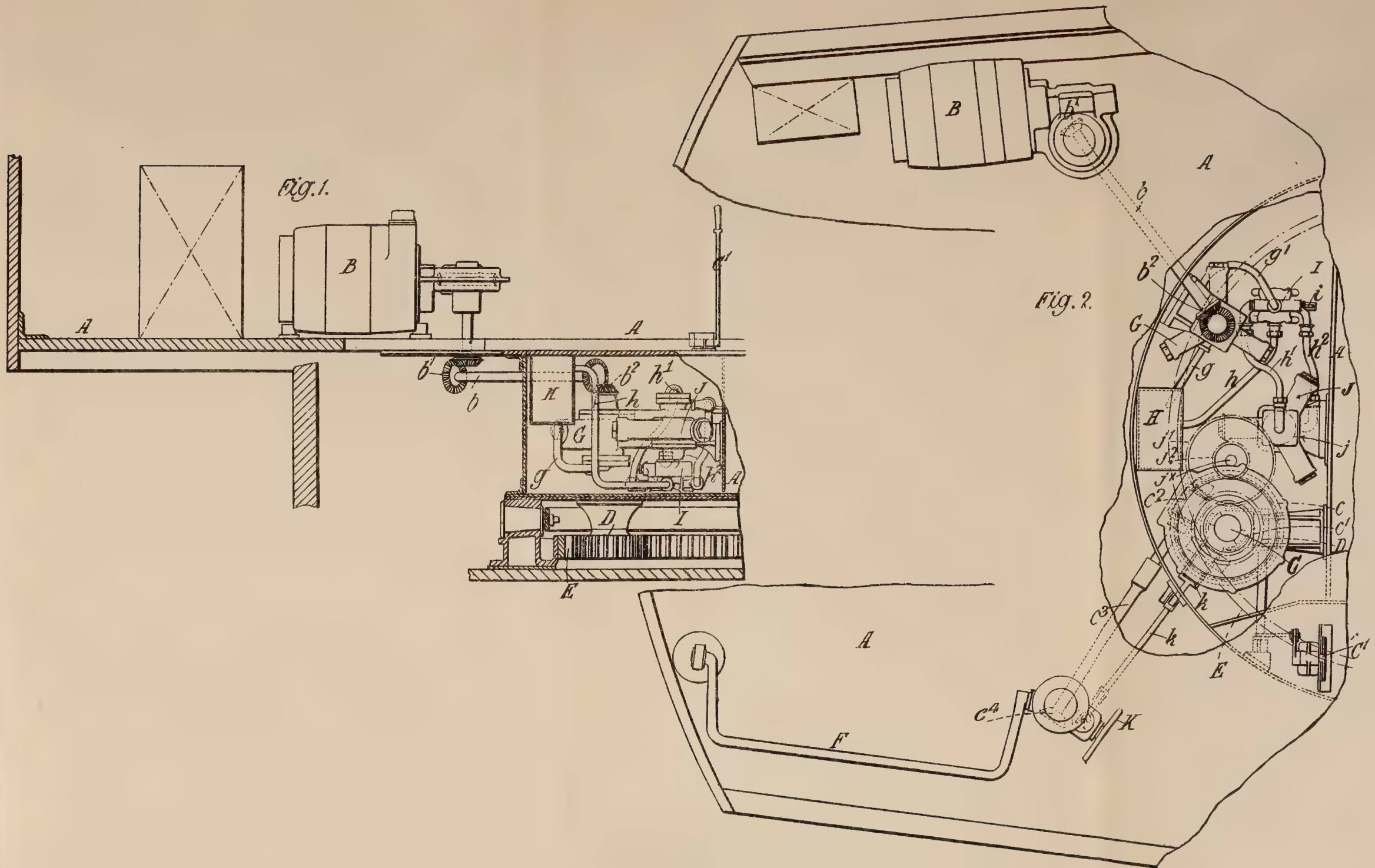
which is mounted on an intermediate shaft j^x having a toothed pinion j^2 that gears with a toothed wheel c on the shaft C carrying the training pinion D. By opening the said valve i to the full extent, all the liquid delivered by the pump G will be supplied to the hydraulic motor J, with the result that the shaft C, and consequently the turntable, will be driven at half full speed. By adjusting the valve i so that it will only allow half the liquid delivered by the pump to reach the motor J, the shaft C will be driven at half full speed, this speed being increased or diminished according as said valve is opened more or less. In other words, the quantity of liquid passing through the valve from the pump G to the motor J in a given time is proportional to the speed of the motor. The passage of the liquid through the pipe h is so arranged that the full pressure required to operate the platform will always be maintained between the pump and the hydraulic motor when the controlling valve is open. When the said valve is adjusted into a central position, all the liquid will be discharged through the pipe h and no motion will be communicated to the platform, but when the valve is moved from this central position, motion will be imparted to the platform in a direction depending upon that in which the valve has been moved and at a speed depending upon the extent to which said valve is shifted.

The shaft C has a worm wheel c^1 loosely mounted thereon, with which worm wheel gears a worm c^2 connected by a shaft c^3 to bevel gearing c^4 that can be actuated by turning the cranked shaft F by hand. The said worm wheel c^1 can be made to revolve with its shaft by actuating a hand lever C^1 , thereby causing a sliding clutch on the shaft C to engage therewith.

The result desired may also be accomplished by using a tram of mechanism, substituting for the hydraulic elements two friction cones of different diameters, a system of differential gear and a friction roller which controls the rates of speed between the two cones.

ELEMENTS OF GUNS.

The following elements of guns and mounts are copies, in each case, of tables supplied by the manufacturer whose name heads the table:



ELECTRO-HYDRAULIC TRAINING GEAR FOR GUN PLATFORMS.



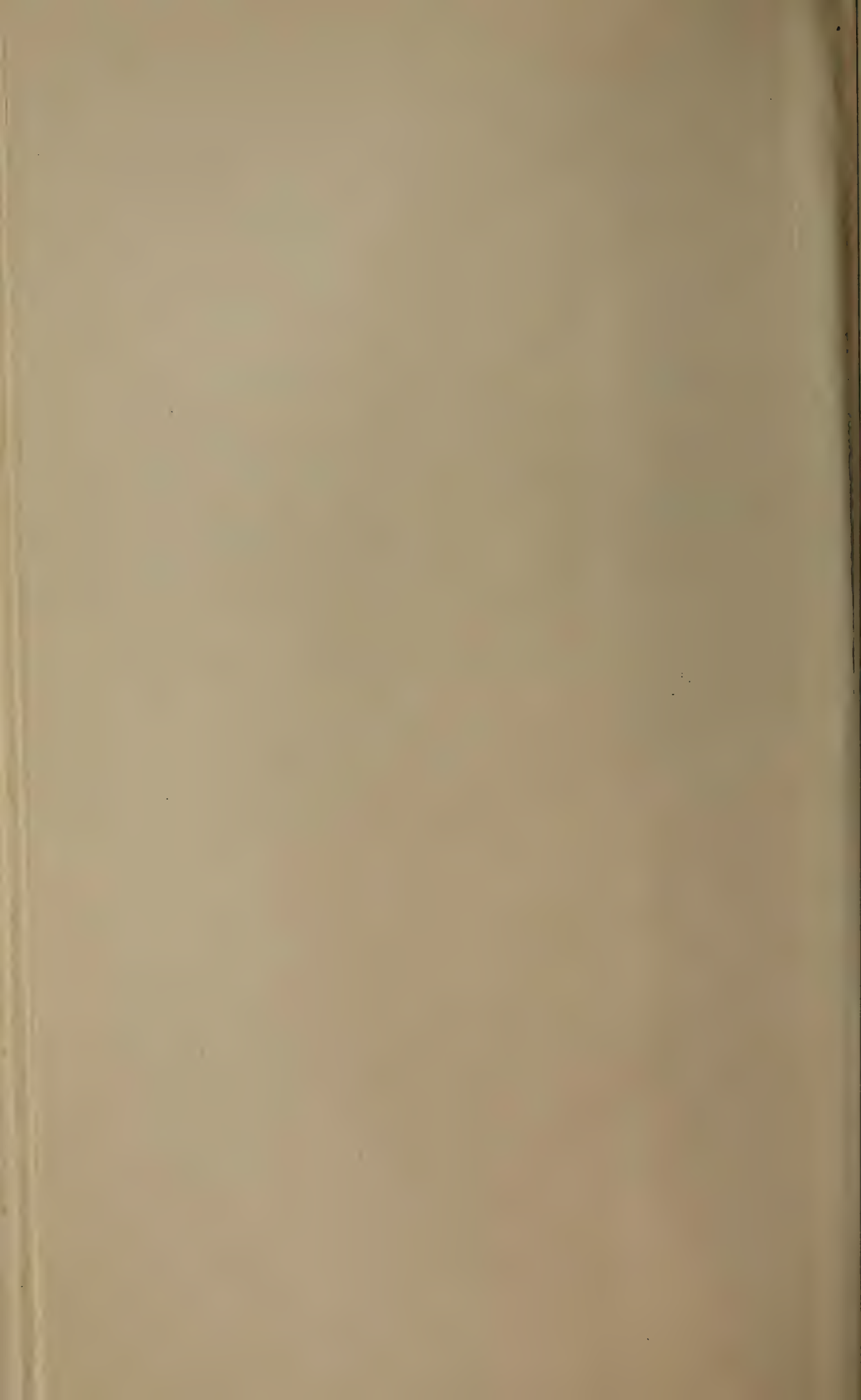
ELSWICK GUNS.

Diameter of bore	1.46			1.85			2.224			3.0			4			4.7			6			7.5			8.0			9.2			10			12		
Do.....	37			47			57			76.2			101.6			120			152			190.5			203			233.7			254			305		
Length of bore	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50
Length of gun	42.8	47.8	52.8	43.6	48.6	53.6	43.6	48.6	53.6	41.2	46.2	51.2	41.3	46.3	51.3	41.1	46.1	51.1	41.55	46.55	51.55	41.75	46.75	51.75	41.75	46.75	51.75	41.85	46.85	51.85	41.65	46.65	51.65	41.7	46.7	51.7
Weight of gun	.103	.117	.13	.212	.238	.264	.306	.412	.46	.78	.88	.98	1.83	2.03	2.32	3.01	3.38	3.77	6.52	7.3	8.1	12.7	14.3	15.9	15.35	17.3	19.3	23.4	26.4	28.4	30.0	32.6	37.5	52.0	58.5	65.2
Weight of projectile.....	1.5	1.5	1.5	3.3	3.3	3.3	6	6	6	14	14	14	31	31	31	45	45	45	100	100	100	200	200	200	250	250	250	380	380	380	500	500	500	850	850	850
Weight of battering charge	5.7 ozs.	6.4 ozs.	7.1 ozs.	11.6 ozs.	13.1 ozs.	14.5 ozs.	1.26 lbs.	1.42 lbs.	1.58 lbs.	3.09 lbs.	3.48 lbs.	3.88 lbs.	7.3 lbs.	8.25 lbs.	9.17 lbs.	11.9 lbs.	13.4 lbs.	14.91 lbs.	24.7 lbs.	27.9 lbs.	31 lbs.	48.4 lbs.	54.5 lbs.	60.6 lbs.	58.6 lbs.	66 lbs.	73.6 lbs.	89.1 lbs.	100.51bs.	111.71bs.	114.51bs.	129 lbs.	143.51bs.	198 lbs.	223 lbs.	248 lbs.
Muzzle velocity	2,510	2,700	2,850	2,450	2,600	2,740	2,390	2,540	2,680	2,460	2,610	2,750	2,530	2,690	2,840	2,690	2,850	3,010	2,650	2,810	2,960	2,620	2,780	2,930	2,580	2,740	2,890	2,580	2,740	2,890	2,550	2,710	2,850	2,570	2,730	2,880
Velocity at 2,500 yards.....	811	834	850	957	988	1,017	1,658	1,111	1,173	1,192	1,260	1,332	1,500	1,601	1,677	1,633	1,711	1,754	1,844	1,950	1,998	1,969	2,088	2,147	1,990	2,116	2,190	2,055	2,186	2,267	2,076	2,213	2,308	2,161	2,306	2,405
Muzzle energy.....	67.2	76	84.5	137	155	172	238	268	299	587	661	734	1,376	1,555	1,735	2,260	2,535	2,830	4,890	5,475	6,075	9,520	10,720	11,906	11,520	13,000	14,480	17,510	19,800	22,000	22,545	25,462	28,161	39,000	43,900	48,800
Penetration at muzzle, wrought iron.....	5.0	5.5	6.0	6.4	7.0	7.55	7.6	8.3	9.0	10.4	11.35	12.3	13.73	15.05	16.30	16.4	17.9	19.55	21.3	23.2	25.15	26.75	29.10	31.65	28.3	31.15	33.7	32.65	35.7	38.6	35.5	39.0	41.9	42.6	46.7	50.9
Rounds per minute guns should be capable of..	30			30			25			20			15			10			8			5			4			2			2			2		

Guns from 3 to 6 inches can be fitted with either a metallic cartridge case or modified De Bange pad. The high velocities, however, are not desirable, except on rare occasions. They are, however, obtained with pressures under 17 tons.

RAPIDITY—SOME RESULTS ACTUALLY OBTAINED.

8-inch 15.5-ton gun, single-motion mechanism, 3 rounds in twenty-eight seconds at drill; 4 rounds in sixty-two seconds on board cruiser *Blanco Encalada* (ammunition brought from magazine).
12-inch 46-ton B. L. gun, H. M. S. *Majestic*, interval between 2 rounds, one minute nineteen seconds; H. M. S. *Cesar*, one minute four seconds.
12-inch B. L. gun, H. M. S. *Illustrious*, 6 rounds fired from one turret in one minute forty-seven seconds.
A pair of 12-inch guns, 8 rounds in two minutes ten seconds.
A pair of 12-inch 51-ton guns, 5 rounds per gun fired alternately, guns started empty, five minutes six seconds.
12-inch B. L. gun, Japanese battleship *Mikasa*, interval between 2 rounds of same gun, thirty seconds.
Ocean (China), prize firing, 1901. 12-inch B. L., 0.58 hits per gun per minute.
Terrible (China), prize firing, 1901. 6-inch Q. F., 4.25 hits per gun per minute.
Barfleur, prize firing, 1901. 4.7-inch Q. F., 5.7 hits per gun per minute.

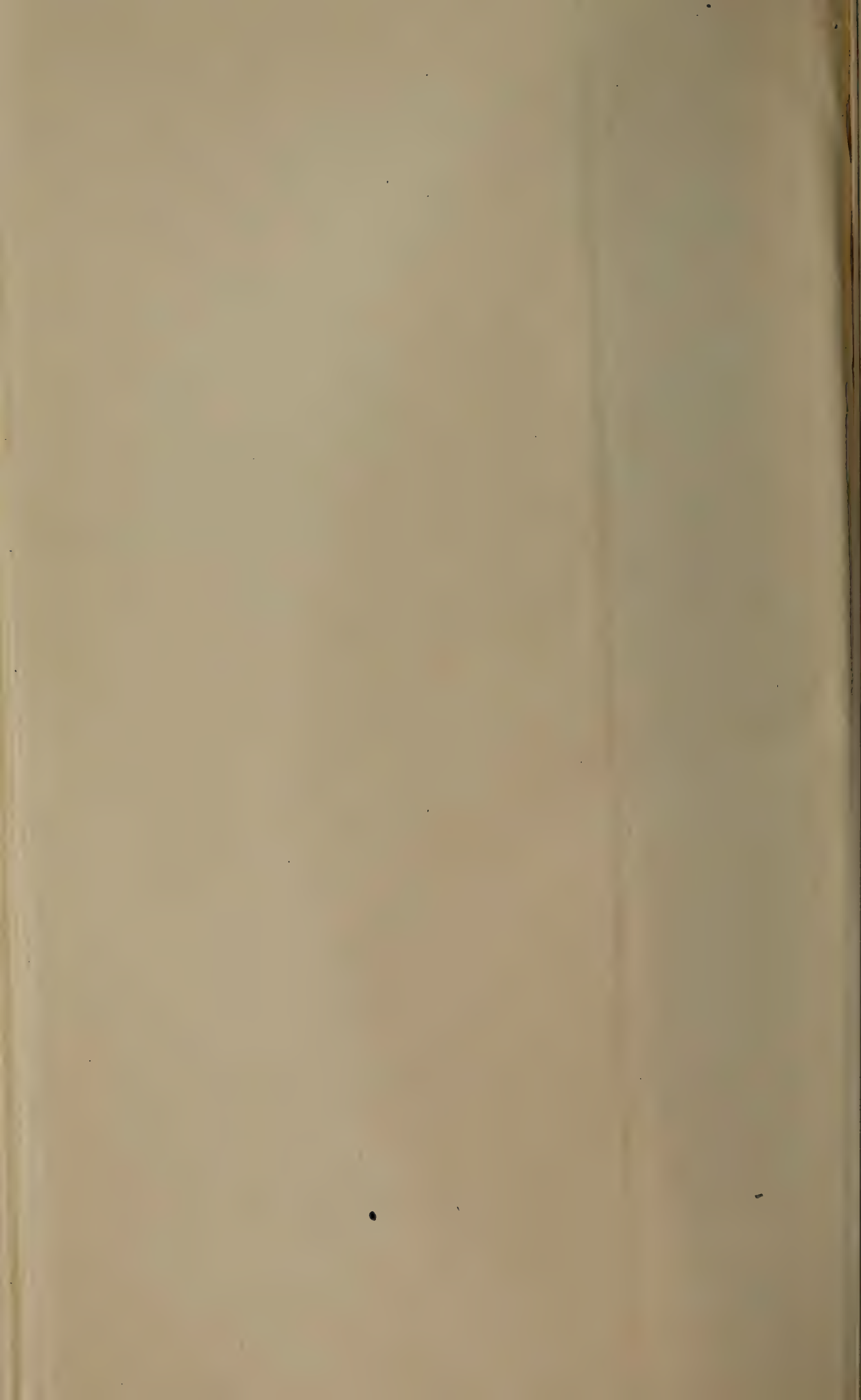


VICKERS, SONS & MAXIM'S GUNS AND MOUNTINGS.

	37 mm., 30 cal.	37 mm., 42.5 cal.	3-pdr., 50 cal.	6-pdr., 42.3 cal.	6-pdr., 50 cal.	Moun- tain; 75 mm., 10.7 cal.	Field.		Naval.		4-inch, 45 cal.	4-inch, 50 cal.	4.7-inch, 45 cal.	4.7-inch, 50 cal.	14 cm., 45 cal.	6-inch, 40 cal.	6-inch, 45 cal.	6-inch, 50 cal.	7.5-inch, 45 cal.	7.5-inch, 50 cal.	8-inch, 45 cal.	9.2-inch, 47 cal.	10-inch, 45 cal.	12-inch, 40 cal.
							Light, 3-inch, 23.7 cal.	Heavy, 3-inch, 29 cal.	3-inch, 45 cal.	3-inch, 50 cal.														
GUN.																								
Diameter of bore.....inches..	1.457	1.457	1.85	2.244	2.744	2.953	3	3	3	3	4	4	4.724	4.724	5.512	6	6	6	7.5	7.5	8	9.2	10	12
Length of bore.....do.....	43.5	62	92.5	95	112.2	31.6	71.05	87.2	136.6	150	180	200	212.6	236.2	248	240	269.5	300	337.5	375	360	429.3	450	480
Total length of gun.....do.....	73.75	94	101.25	104.4	116.4	35.85	74.3	90.63	140.1	154	184.65	206.35	220	243.6	257.7	249.7	279.2	309.73	349.2	386.7	372.1	442.35	462.75	496.5
Maximum pressure in chamber.....tons per square inch..	13	14	16	15	15	8	15	15	17	17	17	17	17	17	16.5	17	17	16	16.5	16.5	17.0	16.5	17	17
Weight of charge.....	oz. grs. 1 110	oz. 3	oz. 13	oz. 15	lb. oz. 1 4	lb. 6.25	lb. oz. 1 1	lb. oz. 1 14	lb. oz. 4 2	lb. oz. 5 3	lb. oz. 8 2	lb. oz. 8 2	lb. oz. 12 14	lb. oz. 12 14	lb. oz. 21 14	lb. oz. 35 5	lb. oz. 35 5	lb. 40	lb. oz. 86 8	lb. oz. 86 8	lb. 94	lb. oz. 162 4	lb. 208	lb. 309
Weight of projectile.....pounds..	1	1.25	3.3	6	6	12.5	12.5	17.63	12.5	12.5	31	31	45	45	88.19	100	100	100	200	200	250	380	500	850
Total weight of gun, including breech mechanism.....	c. q. l. 3 2 24	c. q. l. 5 1 26	c. q. 5 2	c. q. 6 2	c. q. l. 8 0 0	c. q. l. 2 0 13	c. q. l. 4 0 0	c. q. l. 7 1 25	c. q. l. 14 3 0	c. q. l. 16 1 16	t. c. q. 1 14 1	t. c. q. 1 16 1	t. c. q. 3 3 3	t. c. 3 6	t. c. 5 18	t. c. 6 15	t. c. q. 7 8 2	t. c. q. 7 18 3	t. c. q. 14 3 3	t. c. 16 0	t. c. q. 18 16 2	t. c. 28 1	t. c. 31 0	t. c. 50 7
Muzzle velocity.....feet per second..	1,800	2,350	2,800	2,300	2,500	918	1,700	1,700	2,800	3,020	2,945	3,020	2,925	3,000	2,860	2,780	2,860	3,000	2,920	3,018	2,850	2,900	2,850	2,666
Muzzle energy.....foot-tons..	22.5	48	179.4	220	260	73	250.5	353.4	679.5	790	1,865	1,960	2,670	2,810	4,990	5,360	5,670	6,240	11,825	12,630	14,080	22,160	28,160	41,890
Penetration of wrought-iron plate at muzzle by Gavre's formula.....inches..	1.9	3.3	6.7	6.2	7				10.2	11.35	15.4	16	16.65	17.25	22.1	21.2	22.1	23.6	23.9	30.8	31.1	37	40.0	43.8
Penetration of steel plate at muzzle by Gavre's formula, inches.....	1.5	2.6	5.1	4.8	5.4				7.9	8.8	11.9	12.4	12.9	13.4	17.1	16.4	17.1	18.3	22.8	29.4	24.1	28.7	31.1	34
Rounds per minute.....	300	300	30	28	28	14	20	20	20	20	15	15	12	12	10	10	10	10	8	8	6	4	3	2
MOUNTING.							No shield. Weight of equip- ment with—																	
Weight of mounting complete with shield.....	c. q. l. 4 1 10	c. q. l. 3 2 5	c. q. l. 9 0 4	c. q. 12 2	c. q. l. 12 0 0	c. q. l. 5 3 5			t. c. 1 6	t. c. q. 1 10 0	t. c. q. 4 4 3	t. c. q. 4 10 0	t. c. q. 6 5 0	t. c. q. 6 12 0	Depending on type of mounting used.									
Thickness of shield.....inches..		Noshield				Noshield	40 rds.	36 rds.	2	2	4	4	4	4										
Weight of shield.....	q. l. 3 11	"	c. q. l. 1 0 8	c. q. 1 0	c. q. l. 1 3 9	"	t. c. q. l. 1 8 2 5	t. c. q. 1 16 0	c. q. 9 2	c. q. l. 9 0 0	t. c. q. 2 6 0	t. c. q. 2 6 0	t. c. q. 3 18 0	t. c. q. 3 18 0										
Angle of elevation.....	16°	13°	20°	20°	20°	26°	16°	16°	20°	20°	20°	20°	20°	20°										
Angle of depression.....	25°	25°	20°	20°	15°	10°	8°	8°	10°	10°	7°	7°	7°	7°										

VICKERS, SONS & MAXIM'S GUNS AND MOUNTINGS.

	37 mm., 30 cal.	37 mm., 42.5 cal.	3-pdr., 50 cal.	6-pdr., 42.3 cal.	6-pdr., 50 cal.	Moun- tain; 75 mm., 10.7 cal.	Field.		Naval.		4-inch, 45 cal.	4-inch, 50 cal.	4.7-inch, 45 cal.	4.7-inch, 50 cal.	4 in., 45 cal.	6-inch, 40 cal.	6-inch, 45 cal.	6-inch, 50 cal.	7.5-inch, 45 cal.	7.5-inch, 50 cal.	8-inch, 45 cal.	9.2-inch, 47 cal.	10-inch, 45 cal.	12-inch, 40 cal.
							Light, 3-inch, 23.7 cal.	Heavy, 3-inch, 29 cal.	3-inch, 45 cal.	3-inch, 50 cal.														
GUN.																								
Diameter of bore.....inches..	1.457	1.457	1.85	2.244	2.744	2.953	3	3	3	3	4	4	4.724	4.724	5.512	6	6	6	7.5	7.5	8	9.2	10	12
Length of bore.....do....	43.5	62	92.5	95	112.2	31.6	71.05	87.2	136.6	150	180	200	212.6	236.2	248	240	269.5	300	337.5	375	360	429.3	450	480
Total length of gun.....do....	73.75	94	101.25	104.4	116.4	35.85	74.3	90.63	140.1	154	184.65	206.35	220	213.6	257.7	249.7	279.2	309.73	349.2	386.7	372.1	442.35	462.75	496.5
Maximum pressure in chamber....tons per square inch..	13	14	16	15	15	8	15	15	17	17	17	17	17	17	16.5	17	17	16	16.5	16.5	17.0	16.5	17	17
Weight of charge.....	oz. grs. 1 110	oz. 3	oz. 13	oz. 15	lb. oz. 1 4	lb. 6.25	lb. oz. 1 1	lb. oz. 1 14	lb. oz. 4 2	lb. oz. 5 3	lb. oz. 8 2	lb. oz. 8 2	lb. oz. 12 14	lb. oz. 12 14	lb. oz. 21 14	lb. oz. 35 5	lb. oz. 35 5	lb. 40	lb. oz. 86 8	lb. oz. 86 8	lb. 94	lb. oz. 162 4	lb. 208	lb. 399
Weight of projectile.....pounds..	1	1.25	3.3	6	6	12.5	12.5	17.63	12.5	12.5	31	31	45	45	88.19	100	100	100	200	200	250	380	500	850
Total weight of gun, including breech mechanism.....	c. q. l. 3 2 24	c. q. l. 5 1 26	c. q. l. 5 2	c. q. l. 6 2	c. q. l. 8 0 0	c. q. l. 2 0 13	c. q. l. 4 0 0	c. q. l. 7 1 25	c. q. l. 14 3 0	c. q. l. 16 1 16	t. c. q. 1 14 1	t. c. q. 1 16 1	t. c. q. 3 3 3	t. c. 3 6	t. c. 5 18	t. c. 6 15	t. c. q. 7 8 2	t. c. q. 7 18 3	t. c. q. 14 3 3	t. c. 16 0	t. c. q. 18 16 2	t. c. 28 1	t. c. 31 0	t. c. 50 7
Muzzle velocity.....feet per second..	1,800	2,350	2,800	2,300	2,500	918	1,700	1,700	2,800	3,020	2,945	3,020	2,925	3,000	2,860	2,780	2,860	3,000	2,920	3,018	2,850	2,900	2,850	2,666
Muzzle energy.....foot-tons..	22.5	48	179.4	220	260	73	250.5	353.4	679.5	790	1,865	1,960	2,670	2,810	4,990	5,360	5,670	6,240	11,825	12,630	14,080	22,160	28,160	41,890
Penetration of wrought-iron plate at muzzle by Gavre's formula.....inches.....	1.9	3.3	6.7	6.2	7				10.2	11.35	15.4	16	16.65	17.25	22.1	21.2	22.1	23.6	23.9	30.8	31.1	37	40.0	43.8
Penetration of steel plate at muzzle by Gavre's formula, inches.....	1.5	2.6	5.1	4.8	5.4				7.9	8.8	11.9	12.4	12.9	13.4	17.1	16.4	17.1	18.3	22.8	29.4	24.1	28.7	31.1	34
Rounds per minute.....	300	300	30	28	28	14	20	20	20	20	15	15	12	12	10	10	10	10	8	8	6	4	3	2
MOUNTING.							No shield. Weight of equip- ment with—																	
Weight of mounting complete with shield.....	c. q. l. 4 1 10	c. q. l. 3 2 5	c. q. l. 9 0 4	c. q. 12 2	c. q. l. 12 0 0	c. q. l. 5 3 5	40 rds.		t. c. 1 6	t. c. q. 1 10 0	t. c. q. 4 4 3	t. c. q. 4 10 0	t. c. q. 6 5 0	t. c. q. 6 12 0	Depending on type of mounting used.									
Thickness of shield.....inches.....	1	No shield	1	1	1	No shield	36 rds.		2	2	4	4	4	4										
Weight of shield.....	q. l. 3 11	"	c. q. l. 1 0 8	c. q. 1 0	c. q. l. 1 3 9	"	t. c. q. l. 1 8 2 5		c. q. 9 2	c. q. l. 9 0 0	t. c. q. 2 6 0	t. c. q. 2 6 0	t. c. q. 3 18 0	t. c. q. 3 18 0										
Angle of elevation.....	16°	13°	20°	20°	26°	20°	16°		20°	20°	20°	20°	20°	20°										
Angle of depression.....	25°	25°	20°	20°	15°	10°	8°		10°	10°	7°	7°	7°	7°										



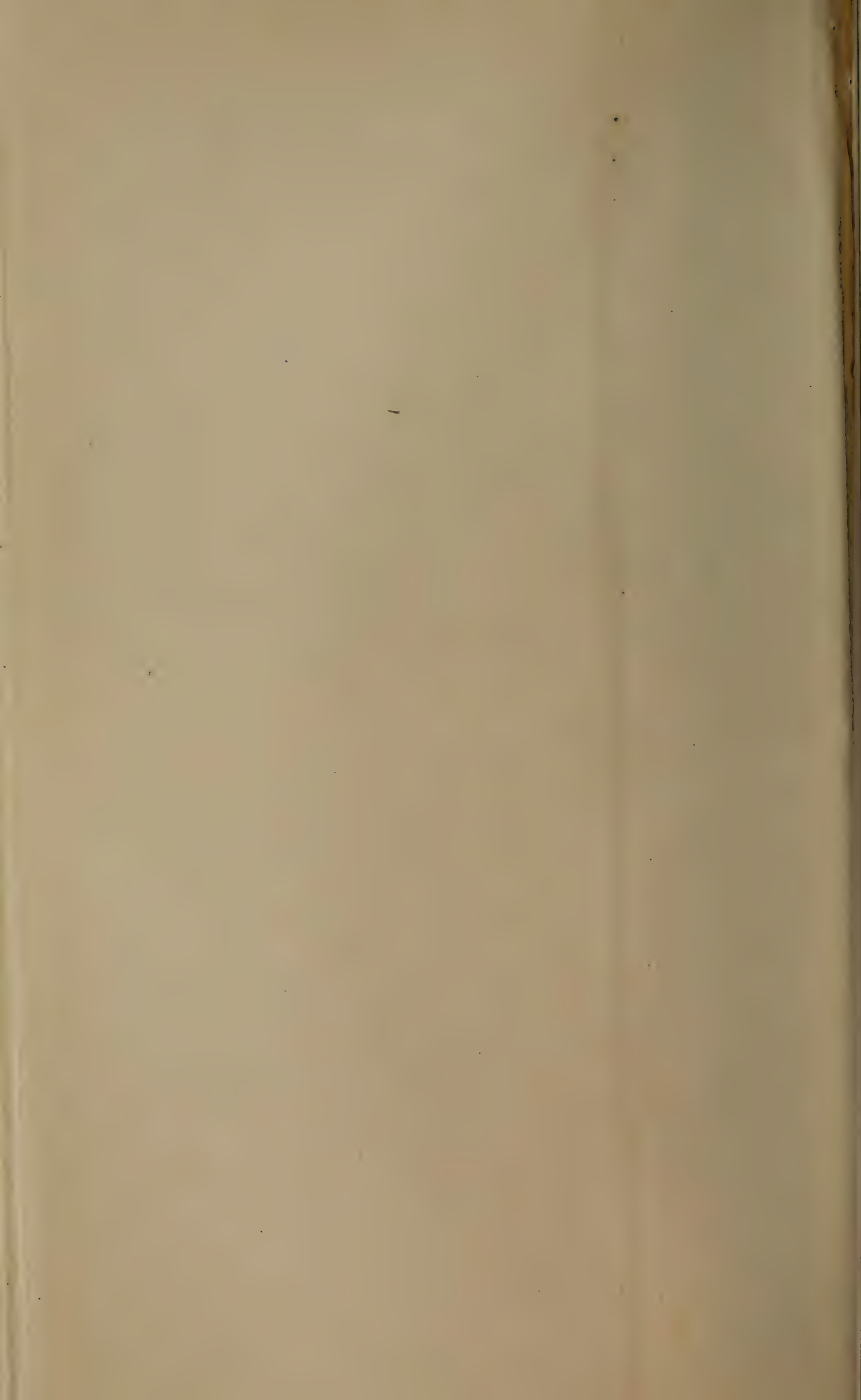
SCHNEIDER-CANET QUICK-FIRE GUNS.

LIGHT GUNS.

Calibre	centimètres..	24		20		15			12			10			75			65			57		47	37
.....inches.....		9.45		7.87		5.91			4.72			3.94			2.95			2.57			2.24		1.85	1.46
Length	calibres..	40	45	40	45	40	45	50	40	45	50	45	50	60	45	59	60	45	50	60	50	60	60	60
.....feet.....		31.5	35.4	26.2	27.5	19.6	22.2	24.6	15.7	17.7	19.7	14.8	16.4	19.7	11.04	12.3	14.8	9.59	10.65	12.8	9.43	11.2	9.24	7.27
Weight of gun	tons..	21.45	22.73	11.61	13.18	4.7	5.6	6.2	2.4	2.75	3	1.7	1.8	2.2	0.8	0.9	1.1	0.5	0.54	0.68	0.45	0.59	0.26	0.14
Weight of projectile	pounds..	331	331	198	198	88.2	88.2	88.2	46.3	46.3	46.3	28.6	28.6	28.6	13.2	13.2	13.2	8.83	8.83	8.83	5.96	5.96	3.3	1.76
Muzzle velocity	foot-seconds..	2,787	2,868	2,787	2,868	2,622	2,721	2,819	2,573	2,670	2,754	2,573	2,688	2,885	2,452	2,590	2,819	2,452	2,590	2,819	2,590	2,787	2,787	2,787
Muzzle energy	foot-tons..	17,748	18,781	10,649	10,694	4,195	4,517	4,839	2,123	2,291	2,430	1,316	1,436	1,646	555	613	726	367	409	487	278	319	177	95
Perforation at muzzle, Gayre formula (forged steel), inches		27.4	28.6	22.8	23.8	15.5	16.4	17.3	11.9	12.6	13.2	10.2	10.9	12.1	7.25	7.9	9	6.3	6.8	7.8	5.8	6.55	5.1	4.2
Perforation at muzzle, Tresidder formula	inches..	32.8	34.2	28.0	29.4	19.7	20.8	22.0	15.7	16.4	17.1	13.5	14.3	15.9	9.7	10.5	11.8	8.4	9.0	10.3	8.1	9.1	7.4	5.8

POWERFUL GUNS.

Calibre	centimètres..	30.5	25.4	24	20.22	20	15	10	6.5	4.7
.....inches.....		12	10	9.45	8	7.87	5.91	3.94	2.57	1.85
Length	calibres..	45	45	45	45	45	50	50	50	60
.....feet.....		45	37.5	35.4	30	29.5	24.6	16.4	10.65	9.24
Weight of guns	tons..	62.9	37.9	30.7	19.48	18.3	8.12	2.4	0.7	0.58
Weight of projectile	pounds..	706.4	408	331	219	198	88.2	28.6	8.83	3.3
Muzzle velocity	foot-seconds..	3,246	3,246	3,246	3,213	3,213	3,181	3,050	2,950	3,607
Muzzle energy	foot-tons..	51,630	29,850	24,203	15,021	14,199	6,196	1,839	536	300
Perforation at muzzle, Gayre (forged steel)	inches..	53,500	31,400	26,000	15,021	14,900	6,196	17.4	10.7	10.7
Perforation at muzzle, Tresidder	do.....	47.3	38.2	34.8	29.2	28.4	20.8	13.2	8.3	7.6
		48.5	39.4	36.7	29.4	29.4	21.0			
		53.5	44.5	41.4	36.0	34.7	26.5			
		52.0	44.0	41.0	33.5	33.5	24.0			



KRUPP QUICK-FIRING GUNS, MARK 1900.

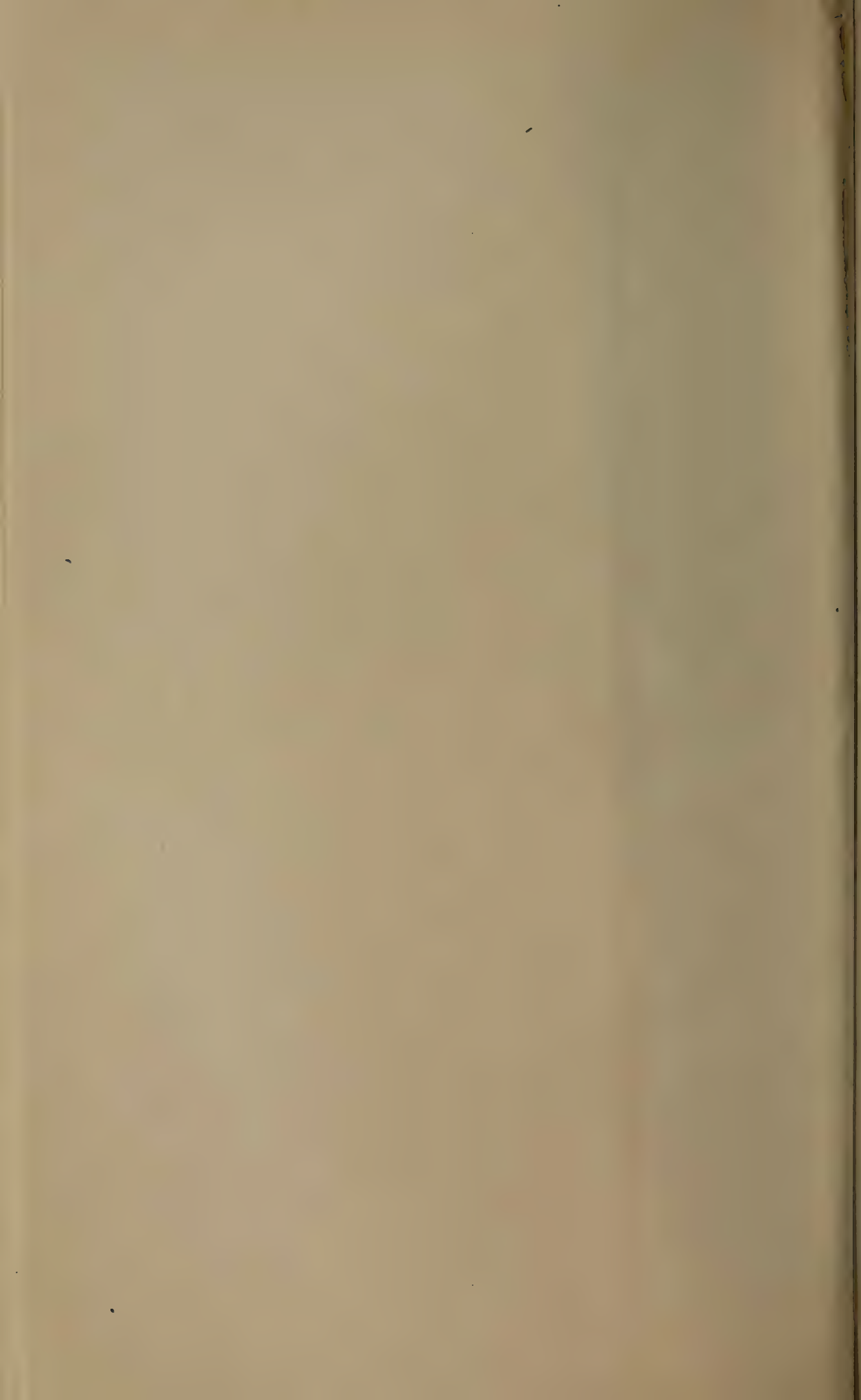
LIGHT GUNS.

Calibre.....	centimètres inches	7.5			10.5			12			15			21			24			28			30.5		
		2.95			4.13			4.72			5.91			8.27			9.45			11.02			12.01		
		40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50
Total length of gun.....	feet.....	9.84	11.07	12.30	13.78	15.5	17.22	15.75	17.7	19.69	19.55	22.0	24.46	27.56	30.9	34.45	31.50	35.4	39.37	36.75	41.3	45.93	40.03	45.0	50.03
	inches.....	108.66	123.43	138.19	153.55	174.21	194.89	175.20	199.25	222.45	218.12	247.49	276.78	305.91	347.29	388.59	350.80	398.28	445.28	409.46	464.62	519.70	445.67	505.95	565.76
Length of bore.....	pounds.....	1,485.9	1,700.9	1,935.7	3,748	4,189	4,740	5,512	6,283	7,055	10,582	12,015	13,558	29,320	33,290	37,254	44,090	50,264	56,443	70,104	79,811	89,503	90,610	10,317	115,742
Weight of gun.....	tons.....	0.69	0.79	0.89	1.73	1.93	2.18	2.54	2.90	3.25	4.88	5.54	6.25	13.51	15.34	17.17	20.32	23.16	26.01	32.31	36.78	41.25	41.76	47.55	53.34
		11.5	11.5	11.5	30.86	30.86	30.86	46.30	46.30	46.30	90.39	90.39	90.39	249.1	249.1	249.1	374.8	374.8	374.8	595.2	595.2	595.2	771.6	771.6	771.6
Weight of steel projectile.....	pounds.....	14.6	14.6	14.6	39.68	39.68	39.68	59.52	59.52	59.52	112.4	112.4	112.4	308.6	308.6	308.6	474.0	474.0	474.0	760.6	760.6	760.6	981.0	981.0	981.0
Weight of charge.....	pounds.....	2.24	2.62	3.07	8.21	9.53	10.87	12.23	14.23	16.25	23.54	27.34	31.19	64.9	75.62	86.42	97.68	113.98	130.07	155.10	181.00	206.57	200.86	233.91	266.93
Muzzle velocity.....	foot-seconds.....	2,385	2,572	2,726	2,638	2,815	2,992	2,674	2,867	3,048	2,651	2,841	3,018	2,657	2,848	3,028	2,657	2,851	3,031	2,661	2,851	3,031	2,654	2,848	3,028
		2,116	2,283	2,418	2,326	2,484	2,638	2,359	2,526	2,687	2,379	2,546	2,707	2,385	2,559	2,720	2,365	2,533	2,697	2,352	2,523	2,680	2,356	2,526	2,684
Muzzle energy.....	total foot-tons.....	452.7	526.0	591	1,491	1,697	1,917	2,298	2,636	2,982	4,408	5,060	5,721	12,198	14,005	15,845	18,362	21,105	23,880	29,204	33,561	37,917	37,756	43,403	49,050
Perforation through steel.....	inches.....	5.97	6.69	7.24	9.8	10.75	11.73	11.58	12.8	13.94	14.65	16.14	17.60	21.06	23.23	25.39	24.33	26.89	29.37	28.74	31.73	34.65	30.6	34.76	37.99
Perforation through iron, Tresidder's formula.....		8.2	9.2	10.1	13.3	14.5	16.0	15.5	17.2	18.8	19.3	21.2	23.2	27.1	30.1	32.9	31.2	34.7	37.8	36.0	40.0	43.8	39.1	43.5	46.4

HEAVY GUNS.

Calibre.....	centimètres inches	7.5			10.5			12			15			21			24			28			30.5		
		2.95			4.13			4.72			5.91			8.27			9.45			11.02			12.01		
		40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50
Total length of gun.....	feet.....	9.84	11.07	12.30	13.78	15.5	17.22	15.75	17.7	19.69	19.55	22.0	24.46	27.56	30.9	34.45	31.50	35.4	39.37	36.75	41.3	45.93	40.03	45.0	50.03
	inches.....	108.66	123.43	138.19	153.55	174.21	194.89	175.20	199.25	222.45	218.12	247.49	276.78	305.91	347.29	388.59	350.80	398.28	445.28	409.46	464.62	519.70	445.67	505.95	565.76
Length of bore.....	pounds.....	1,860.7	2,094.4	2,325.8	4,519.2	5,115.1	5,688	6,724.2	7,606.2	8,488	12,897	14,661	16,314	35,711	40,341	44,972	53,792	60,843	67,904	85,544	96,784	108,030	110,671	125,003	139,772
Weight of gun.....	tons.....	0.85	0.96	1.07	2.08	2.35	2.62	3.10	3.51	3.91	5.94	6.76	7.52	16.46	18.59	20.73	24.79	28.04	31.29	39.42	44.60	49.79	51.00	57.61	64.42
		11.5	11.5	11.5	30.86	30.86	30.86	46.30	46.30	46.30	90.39	90.39	90.39	249.1	249.1	249.1	374.8	374.8	374.8	595.2	595.2	595.2	771.6	771.6	771.6
Weight of steel projectile.....	pounds.....	14.6	14.6	14.6	39.68	39.68	39.68	59.52	59.52	59.52	112.4	112.4	112.4	308.6	308.6	308.6	474.0	474.0	474.0	760.6	760.6	760.6	981.0	981.0	981.0
Weight of charge.....	pounds.....	2.43	2.78	3.15	8.71	10.12	11.53	13.01	15.10	17.22	24.91	28.88	33.04	68.78	80.03	91.49	103.84	120.59	137.79	165.12	191.80	218.70	213.40	247.58	282.85
Muzzle velocity.....	foot-seconds.....	2,484	2,661	2,822	2,723	2,910	3,094	2,763	2,976	3,159	2,743	2,949	3,133	2,749	2,953	3,140	2,746	2,956	3,143	2,749	2,959	3,140	2,746	2,953	3,140
		2,205	2,362	2,507	2,402	2,566	2,730	2,438	2,625	2,785	2,457	2,644	2,808	2,467	2,654	2,822	2,441	2,628	2,795	2,431	2,618	2,776	2,434	2,618	2,785
Muzzle energy.....	total foot-tons.....	490.5	562.8	633.8	1,588	1,814	2,049	2,452	2,840	3,204	4,711	5,450	6,151	13,037	15,070	17,039	19,588	22,702	25,655	31,205	36,142	40,725	40,338	46,695	52,729
Perforation through steel.....	inches.....	6.39	7.01	7.64	10.28	11.26	12.32	12.13	13.50	14.69	15.36	17.01	18.54	22.13	24.49	26.73	25.47	28.31	30.87	30.12	33.47	36.42	32.4	36.65	40.08
Perforation through iron, Tresidder's formula.....		8.7	9.7	10.6	13.9	15.4	16.8	16.3	18.1	19.8	20.1	22.3	24.5	28.5	31.8	34.6	32.7	36.3	39.8	37.6	42.2	46.5	41.0	45.8	50.1

NOTE.—Every one of the guns included in the tables has been actually constructed and can be supplied on order.



KRUPP QUICK-FIRING GUNS, MARK 1901.

LIGHT GUNS.

Caliber	centimeters..	7.5			10.5			12.0			15.0			21.0			24.0			28.0			30.5		
	inches	2.95			4.13			4.72			5.91			8.27			9.45			11.02			12.01		
Total length of gun	calibers..	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50
	feet	9.84	11.07	12.30	13.78	15.5	17.22	15.75	17.7	19.69	19.55	22.00	24.44	27.56	30.9	34.45	31.50	35.4	39.37	36.75	41.3	45.93	40.03	45.0	50.03
Length of bore	inches..	108.66	123.43	138.19	153.55	174.21	194.89	175.20	199.25	222.45	218.12	247.49	276.78	305.91	347.29	388.59	350.80	398.28	445.28	409.46	464.62	519.70	445.67	505.95	565.76
Weight of gun	pounds..	1,488	1,711	1,936	3,748	4,189	4,740	5,512	6,283	7,055	10,582	12,015	13,558	29,321	33,290	37,254	44,090	50,264	56,443	70,104	79,811	89,503	90,610	103,174	115,742
	tons	0.68	0.79	0.89	1.73	1.93	2.18	2.54	2.90	3.25	4.88	5.54	6.25	13.51	15.34	17.17	20.32	23.16	26.01	32.31	36.78	41.25	41.76	47.55	53.34
Weight of steel projectile	pounds..	11.5	11.5	11.5	30.86	30.86	30.86	46.30	46.30	46.30	90.39	90.39	90.39	249.1	249.1	249.1	374.8	374.8	374.8	595.2	595.2	595.2	771.6	771.6	771.6
	do	11.6	14.6	14.6	39.68	39.68	39.68	59.52	59.52	59.52	112.4	112.4	112.4	308.6	308.6	308.6	474.0	474.0	474.0	760.6	760.6	760.6	981.0	981.0	981.0
Weight of charge	do	2.77	3.12	3.54	9.30	10.83	12.34	13.93	16.11	18.43	26.67	30.95	35.40	74.07	85.74	97.97	111.23	128.97	147.27	176.59	205.25	234.57	228.61	264.99	303.13
	foot-seconds..	2,690	2,890	3,068	2,835	3,035	3,232	2,900	3,097	3,291	2,877	3,068	3,264	2,884	3,081	3,271	2,884	3,081	3,268	2,887	3,081	3,271	2,881	3,074	3,268
Muzzle velocity	do	2,388	2,566	2,723	2,500	2,674	2,851	2,559	2,730	2,904	2,579	2,753	2,927	2,592	2,766	2,940	2,562	2,736	2,907	2,552	2,723	2,894	2,552	2,726	2,897
	total foot-tons..	576	665	749	1,720	1,968	2,236	2,701	3,079	3,475	5,183	5,905	6,680	14,360	16,361	18,491	21,589	24,622	27,817	34,867	39,143	44,242	44,371	70,349	57,182
Perforation, steel	inches..	7.13	7.91	8.58	10.87	11.97	13.15	12.99	14.25	15.59	16.46	18.03	19.69	23.66	26.02	28.35	27.32	30.0	32.68	32.28	35.43	38.62	35.36	38.82	42.36
	do	9.9	11.0	11.7	14.7	16.3	18.0	17.6	19.4	21.0	21.8	23.9	26.2	30.7	33.5	37.0	35.0	38.6	42.1	40.7	35.5	48.9	44.2	48.6	53.3

HEAVY GUNS.

Caliber	centimeters..	7.5			10.5			12.0			15.0			21.0			24.0			28.0			30.5		
	inches	2.95			4.13			4.72			5.91			8.27			9.45			11.02			12.01		
Total length of gun	calibers..	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50	40	45	50
	feet	9.84	11.07	12.30	13.78	15.5	17.22	15.75	17.7	19.6	19.55	22.00	24.44	27.56	30.9	34.45	31.50	35.4	39.37	36.75	41.3	45.93	40.03	45.0	50.03
Length of bore	inches..	108.66	123.43	138.19	153.55	174.21	194.89	175.20	199.25	222.45	218.12	247.49	276.78	305.91	347.29	388.59	350.80	398.28	445.28	409.46	464.62	519.70	445.67	505.95	565.76
Weight of gun	pounds..	1,861	2,094	2,326	4,519	5,115	5,688	5,842	6,724	7,606	11,244	12,897	14,661	31,080	35,711	40,341	46,741	53,792	60,843	74,514	85,544	96,784	96,343	110,671	125,003
	tons	0.85	0.96	1.07	2.08	2.35	2.62	2.70	3.10	3.51	5.18	5.94	6.76	14.32	16.46	18.59	21.54	24.79	28.04	34.34	39.42	44.60	44.40	51.0	57.61
Weight of steel projectile	pounds..	11.5	11.5	11.5	30.86	30.86	30.86	46.30	46.30	46.30	90.39	90.39	90.39	249.1	249.1	249.1	374.8	374.8	374.8	595.2	595.2	595.2	771.6	771.6	771.6
	do	11.6	14.6	14.6	39.68	39.68	39.68	59.52	59.52	59.52	112.4	112.4	112.4	308.6	308.6	308.6	474.0	474.0	474.0	760.6	760.6	760.6	981.0	981.0	981.0
Weight of charge	do	2.99	3.35	3.76	10.16	11.63	13.18	15.10	17.80	20.30	28.88	34.17	39.02	80.03	94.71	108.10	120.60	142.41	162.48	191.80	226.41	258.60	248.02	292.77	334.0
	foot-seconds..	2,876	2,999	3,123	2,949	3,150	3,337	2,933	3,146	3,353	2,910	3,120	3,320	2,917	3,130	3,330	2,917	3,130	3,330	2,917	3,130	3,330	2,917	3,127	3,330
Muzzle velocity	do	2,664	2,775	2,885	2,602	2,779	2,946	2,588	2,776	2,959	2,608	2,799	2,979	2,621	2,812	2,992	2,595	2,782	2,963	2,582	2,769	2,949	2,585	2,772	2,953
	total foot-tons..	620	703	795	1,862	2,123	2,391	2,762	3,182	3,611	5,308	6,109	6,922	14,683	16,926	19,168	22,121	25,461	28,849	35,174	40,499	45,888	45,501	52,277	59,280
Perforation, steel	inches..	7.52	8.23	8.98	11.50	12.68	13.74	13.23	14.61	16.02	16.73	18.47	20.16	24.06	26.61	29.06	27.80	30.71	33.58	32.84	36.34	39.65	35.98	39.76	48.51
	do	10.5	11.3	12.0	15.6	17.4	19.0	17.8	19.8	21.6	22.0	23.8	26.8	31.3	34.4	38.0	34.8	38.8	43.4	41.6	45.1	50.2	45.2	48.8	54.2

NOTE.—Every one of the guns included in the tables has been actually constructed and can be supplied on order.

BETHLEHEM STEEL COMPANY.

ORDNANCE.

Nature of gun.	Caliber in inches.	Caliber in centimeters.	Length of bore.	Length of gun.	Weight of gun.	Charge of smokeless powder.	Weight of projectile.	Muzzle velocity.	Muzzle energy.	Perforation at muzzle of U. S. standard face-hardened armor by capped A. P. projectiles.
			<i>Cals.</i>	<i>Cals.</i>	<i>Lbs.</i>	<i>Oz.</i>	<i>Lbs.</i>	<i>Ft. seconds.</i>	<i>Foot-tons.</i>	
1-pounder	1.457	3.7	46.4	50	120	3	1	2,300	37	.....
3-pounder	1.851	4.7	46	50	550	19.5	3.3	2,300	121	2
6-pounder	2.244	5.8	50	54	960	21	6	2,400	240	2.5
3-inch Q. F.	3	7.62	50	51.4	1,900	<i>Lbs.</i> 4	15	2,400	599	3.9
4-inch Q. F.	4	10.16	50	51	<i>Tons.</i> 2.6	15	33	2,900	1,924	6.8
4.7-inch Q. F.	4.7	12	48.5	50	3.9	14	45	2,800	2,445	7.2
5-inch Q. F., No. 1 ^a	5	12.7	45.1	46.3	3.4	9.5	45	2,200	1,510	5.2
5-inch Q. F., No. 2	5	12.7	45.1	45.9	3.4	14	55	2,600	2,577	7.1
5-inch Q. F., No. 3 ^b	5	12.7	50	51.1	4.0	27	50	2,900	3,207	7.7
6-inch Q. F., No. 1 ^b	6	15.24	41	42.3	6.1	16	100	2,200	3,355	7.5
6-inch Q. F., No. 2	6	15.24	44	45	7.1	20	100	2,500	4,383	8.8
6-inch Q. F., No. 3	6	15.24	50	51.5	7.9	46	100	2,900	5,830	10.6
8-inch Q. F., No. 1	8	20.32	45	46.5	16.6	90	250	2,500	10,833	13
8-inch, No. 2 ^a	8	20.32	32	35	9.6	83	300	2,300	10,528	13.2
10-inch, No. 1 ^a	10	25.4	34.7	36.7	30	140	575	2,300	21,086	17.2
10-inch, No. 2	10	25.4	40	41.4	32	140	500	2,500	21,665	17.5
10-inch shell gun	10	25.4	28.2	30	13	100	400	2,200	13,420	13
12-inch ^a	12	30.48	35.3	36.9	51	240	1,000	2,300	36,671	21.7
12-inch mortar ^{a c}	12	30.48	10	11.76	13	50	800	1,325	9,736	9.5
18-inch shell gun	18	45.72	28	29.3	60	<i>d</i> 400	2,000	<i>c</i> 2,250	70,185	25.3

Guns from 3 inches to 6 inches fitted with either a metallic cartridge case or a Debangé pad.

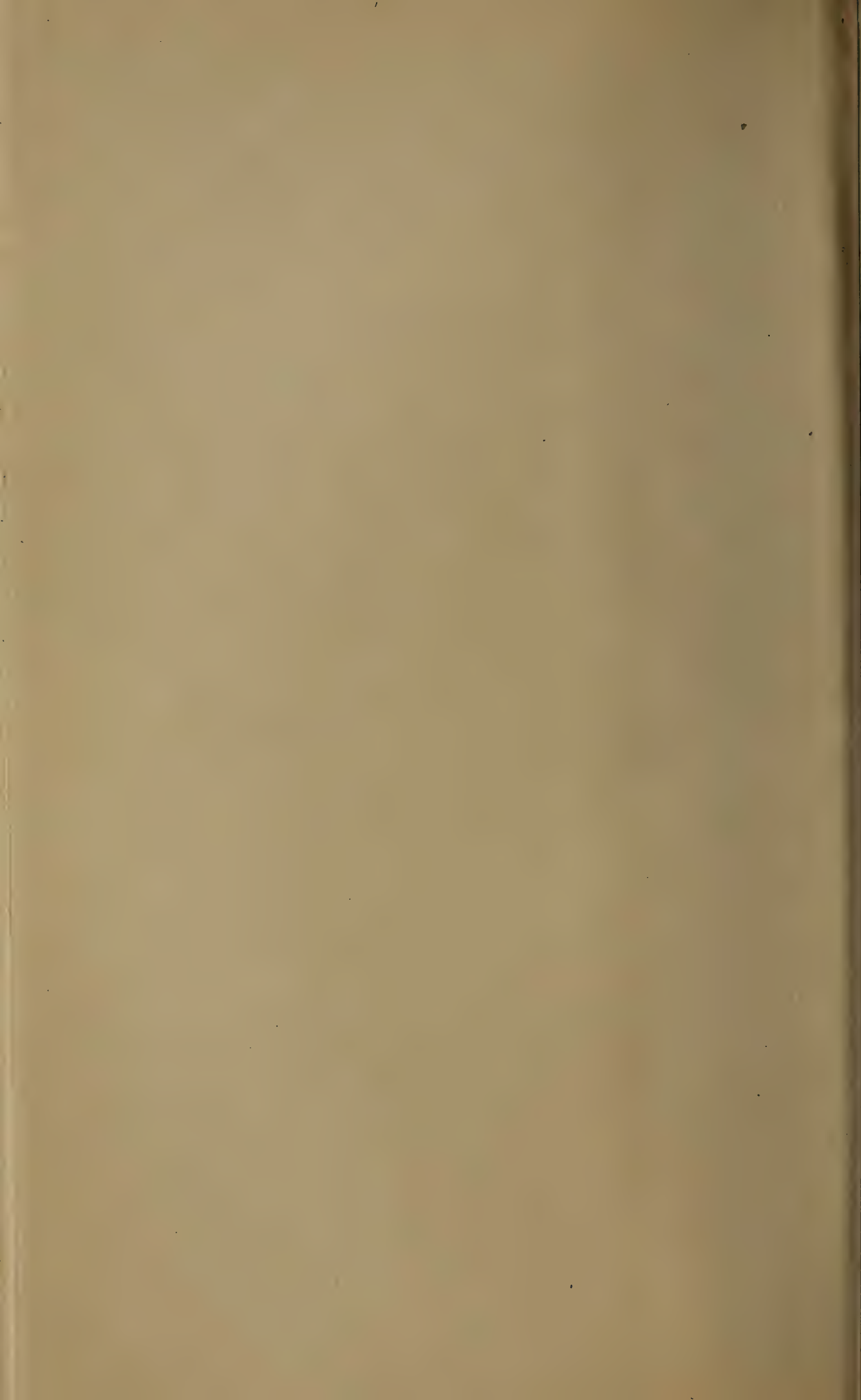
^a U. S. army type.

^b U. S. navy type.

^c These mortars have been found very accurate at ranges up to 10,000 yards when fired at obscured targets representing a ship's deck.

^d 75 per cent cellulose, 25 per cent nitroglycerine.

^e This velocity is reached, allowing the usual factor of safety for the gun. With an 1,830-pound explosive shell (500 pounds of wet gun cotton), a velocity of 1,980 foot-second was reached with 8.2 tons pressure.



SECTION II.

ARMOR.

With one or two exceptions, the trials of the year have been acceptance trials of plates, throughout which the Krupp process retained its established position. The Krupp cemented process, best for plates from 6 to 9 inches, has not been satisfactorily extended to plates thicker than 9 inches or thinner than 6 inches. The Krupp non-cemented process plates (K. N. C. plates) appear to lack uniformity, one portion of the plate possessing characteristics quite different from another portion. British projectiles are tested against K. N. C. plates. The results are seldom published.

Plates for the British armored cruisers *Drake* and *Essex* were found to vary considerably in homogeneity. In some places a drill or a chisel would not touch them, in others, the drill produced a fine powder, while other portions were cut with ease.

The resistance of the K. C. plate is reported as being about 20 per cent higher than that of K. N. C. plates.

Krupp's processes are still considered as standard, and have recently been applied, in one form, to the production of curved armor possessing qualities equal to those of the K. C. plate.

A German chemist, Giebler by name, is reported to have discovered a process for hardening armor which, while increasing its resistance two or three times as compared with the best armor of present makers, is stated to reduce the cost of manufacture by two-thirds of the present outlay.

Experiments under this process were carried out with plates of only 7.5 millimeters thickness. No definite details of its further development have been published.

In the matter of trials, two have been of particular interest, one to test the Johnson cap, during which trial a 6-inch shot was fired through 12-inch K. C. plate, and the other tests of 6-inch plates hardened by the Beardmore process. The results of these tests are given in pages following.

TESTS OF 6-INCH AND 7.5-INCH GUNS AGAINST 6-INCH AND 12-INCH CEMENTED (KRUPP) STEEL ARMOR PLATES.

The plates, as shown on the engravings, are 6 inches and $11\frac{3}{8}$ inches—practically 12 inches—in thickness, and were manufactured to Admiralty specifications. The first of the trials took place on May 9, 1902, when the controller of the navy and other naval officials

were present. The remainder of the shots were fired on the 23d, when practically the whole Board of Admiralty was present.

The attack on the 9th was against the 12-inch plate. The results are set out in Table I. The first round from the 6-inch gun, with a capped projectile at the high striking velocity of 2,799 foot-seconds, completely perforated the plate, although the projectile was broken up. The second shot, without cap, penetrated $3\frac{3}{4}$ inches, and the third, an explosive shell from the 7.5-inch gun, was buried deep in the plate, as shown. A probe could be inserted round the edge to a depth of 7 inches. On the 23d two further shots were fired at this plate, both from the 6-inch gun, as recorded in Table II, the one with a cap going through the plate, and remained in the backing; but the fifth shot, without a cap, was broken up, and measurement showed that it had only penetrated to a depth of 3 inches.

The attack on the 6-inch plate on May 23 consisted of three rounds, the first and third from a 6-inch gun, and the second from the 7.5-inch weapon. Both guns using capped projectiles completely defeated the plate, the 7.5-inch explosive shell passing through it. The greater part (92 pounds) was discovered bedded in a sand heap beyond the target, but the 6-inch shot without a cap made no impression on the plate.

TABLE I (see fig. 1).—First, second, and third rounds against 11 $\frac{1}{16}$ -inch plate.

Date: May 9, 1902. Firing at Eskmeals range for trial of 7.5-inch and 6-inch Vickers armor-piercing projectiles fitted with Johnson cap against a 12-inch Vickers K. C. plate, No. 4865. Ordnance No.: 1037A, 6-inch B. L., Mark B., and No. 1017A, 7.5-inch B. L., 50 calibers. Mountings: Naval pedestal.

Round.	Charge.		Projectile and fuse.	Mean muzzle velocity.	Temperature of charge, 80° F. Thermometer { Dry bulb, 48° F. Wet bulb, 47° F. Barometer..... 30.25 inches.		
	Nature.	Weight.			Striking velocity.	Striking energy.	Ramming.
		Pounds.		Foot-sec.	Foot-sec.	Foot-tons.	Inches.
1.....	R. R. 384, nitro-cellulose.	34	Vickers 6-in. A. P. shot, fitted with Johnson cap, 105 lbs.	2,856	2,799	5,705	41.65
2.....	do	34	Vickers 6-in. A. P. shot, without cap, 100 lbs.	2,880	2,820	5,513	41.55
3.....	Cordite $\frac{38}{100}$	43	Vickers 7.5-in. A. P. shell, fitted with Johnson cap, 205 lbs.	2,480	2,424	8,492	66.75

Round 1.—Completely perforated plate. Projectile was broken up. Penetration measured 18 inches to base of shot; after removing its fragments the penetration measured 23 $\frac{3}{4}$ inches. Extent of injury by scaling, 18.5 inches H. by 20.5 inches V. No cracks. Diameter of hole 6 inches. This shot struck exactly in front of a horizontal H girder, and bulged it back 1 $\frac{1}{2}$ inches; otherwise it would have gone completely through.

Round 2.—Projectile completely broken up. Penetration about 3 $\frac{3}{4}$ inches; but point of shot remained fused in plate. Extent of injury by scaling, 18 $\frac{1}{2}$ inches H. by 19 inches V. No cracks. Diameter of portion of shot in hole equals 8 inches. There was no trace of bulge at back, or any displacement of backing.

Round 3.—Projectile broken up, but all the point portion, including 2 inches of core, remained in plate; it was not, however, fused in as in round 2, for a feeler could be inserted in many places round the periphery up to 7 inches from face of plate. Penetration to front end of core was 5 inches. If, therefore, the point preserved its profile, the total penetration would be 9 $\frac{1}{2}$ inches. Base portion set up and part flowed in molten state into the front of core, molding itself to its contour. Extent of injury, 23.5 inches H. by 21.5 inches V.

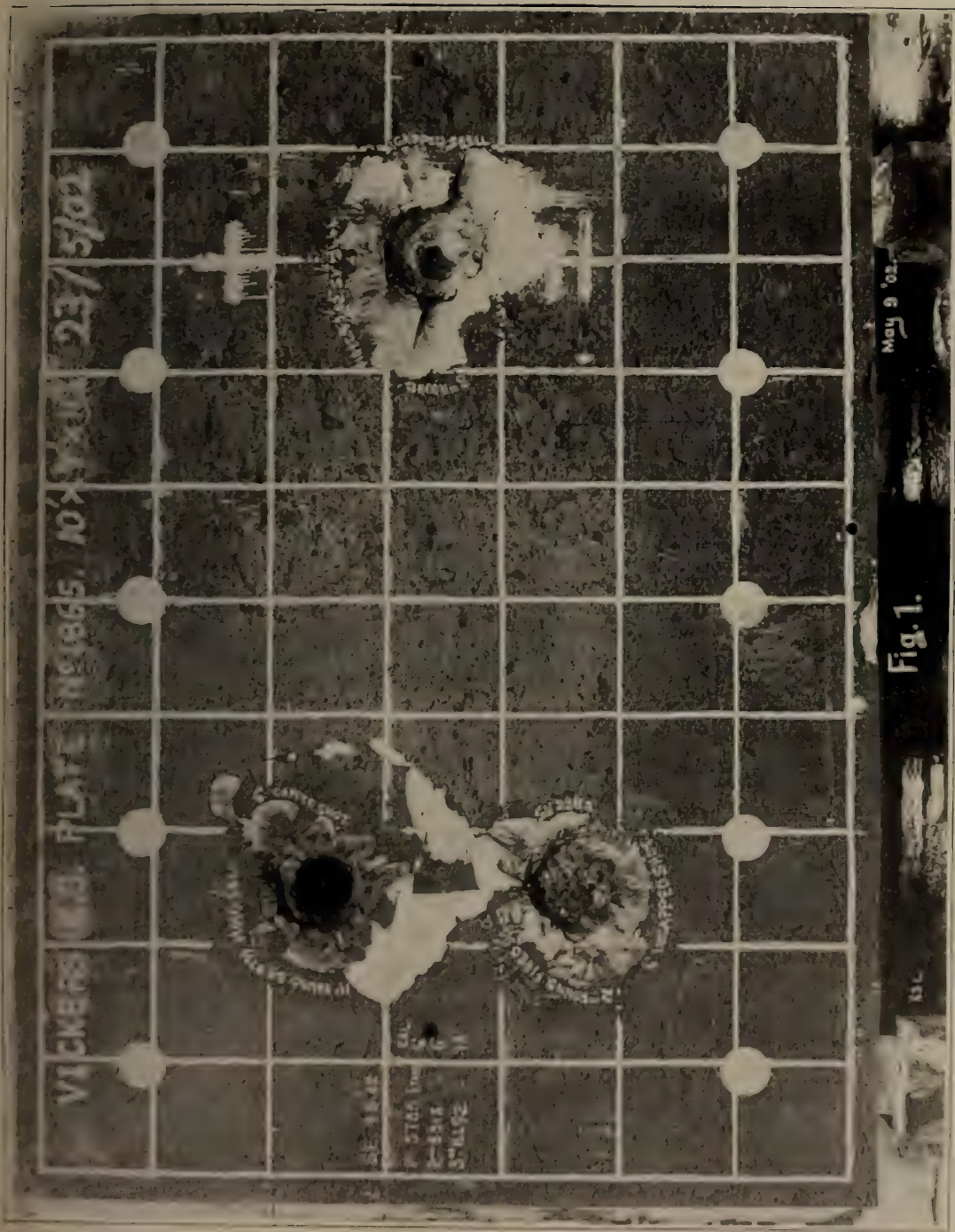
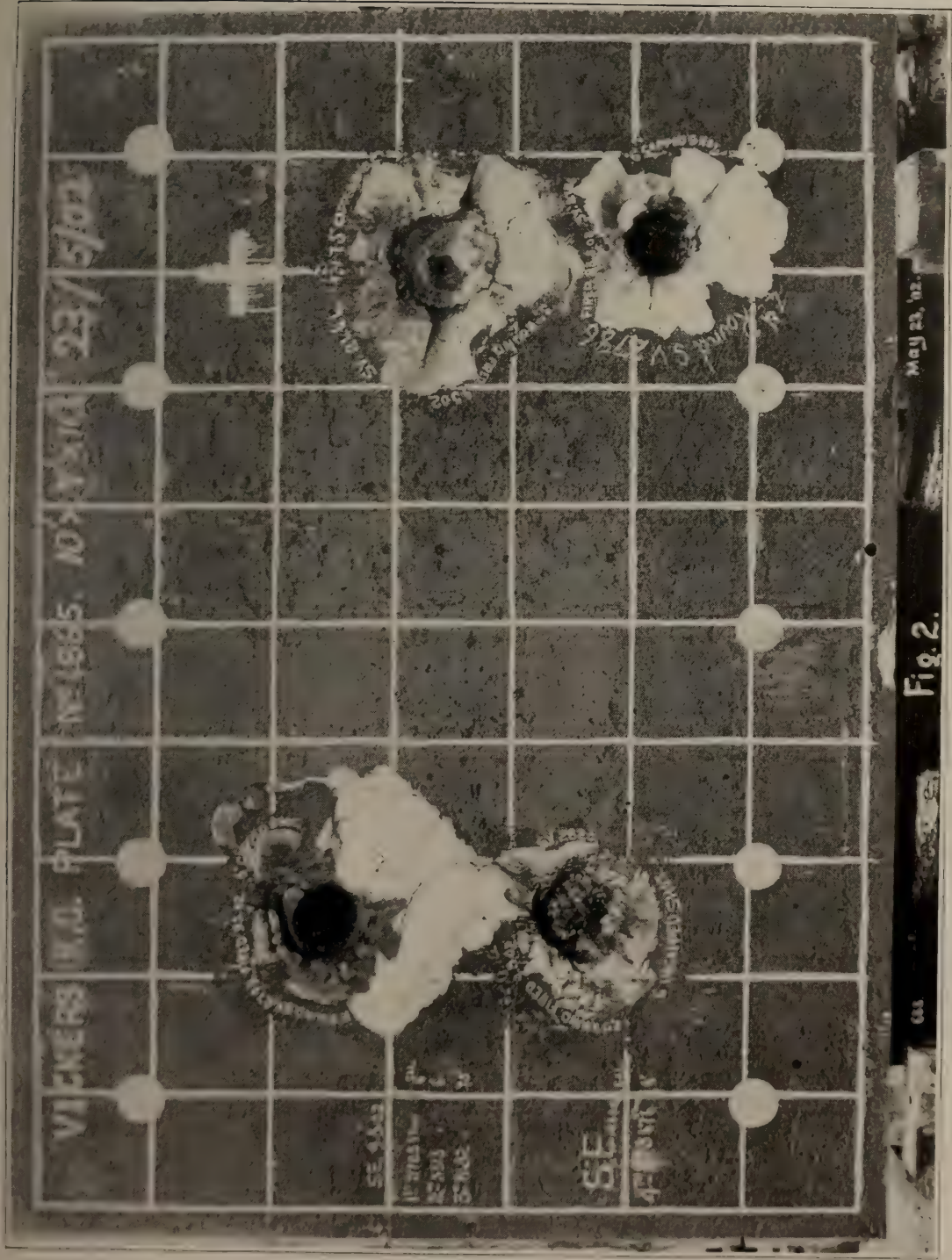


Fig. 1.

TESTS OF 6-INCH AND 7.5-INCH CAPPED AND UNCAPPED PROJECTILES AGAINST 11 $\frac{1}{8}$ -INCH (K. C.) PLATE.



TESTS OF 6-INCH AND 7.5-INCH CAPPED AND UNCAPPED PROJECTILES AGAINST 11 1/8-INCH (K. C.) PLATE.

Fig. 3.

TESTS OF 6-INCH AND 7.5-INCH CAPPED AND UNCAPPED PROJECTILES AGAINST 11¹³-INCH (K. C.) PLATE.

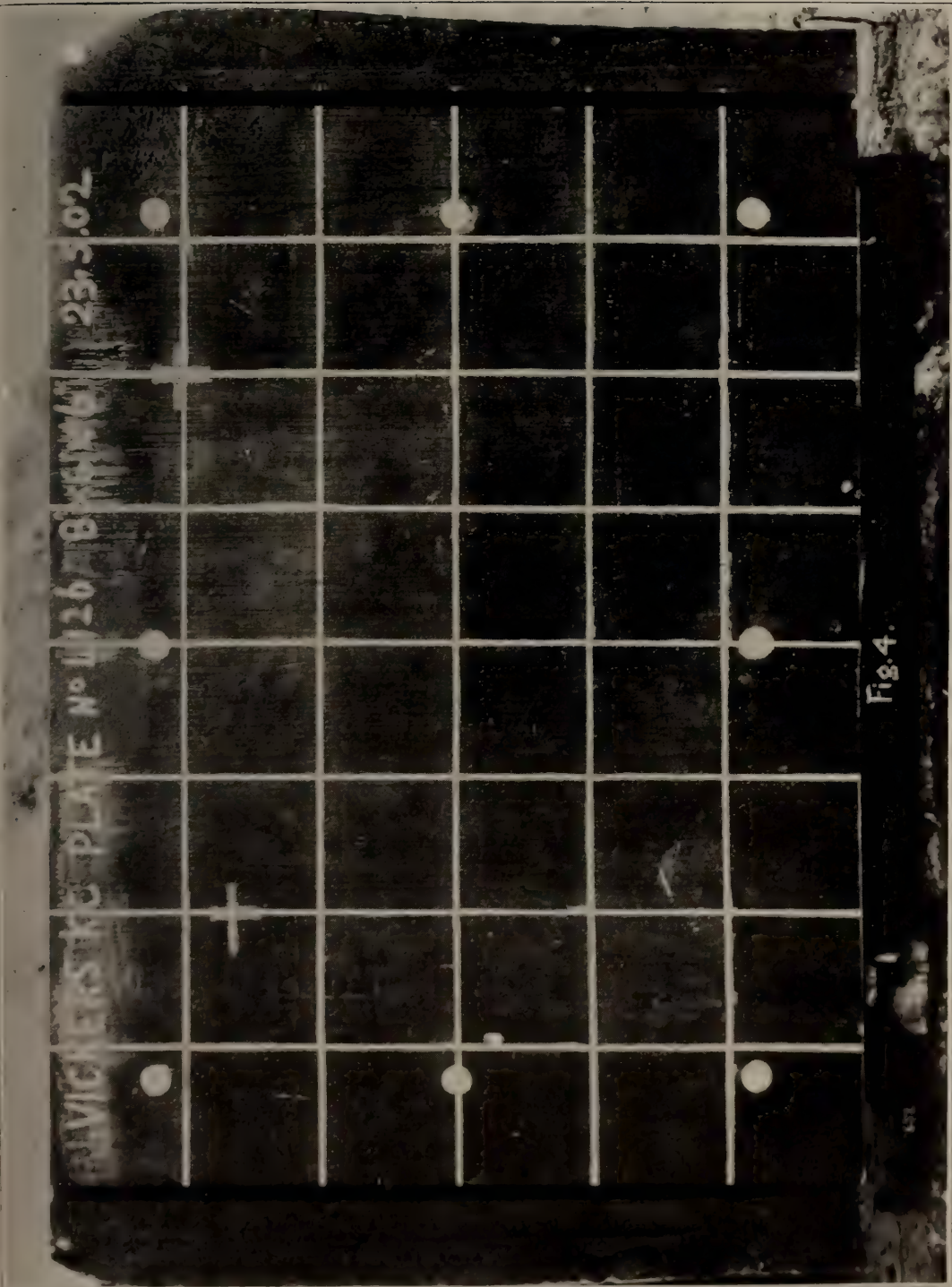
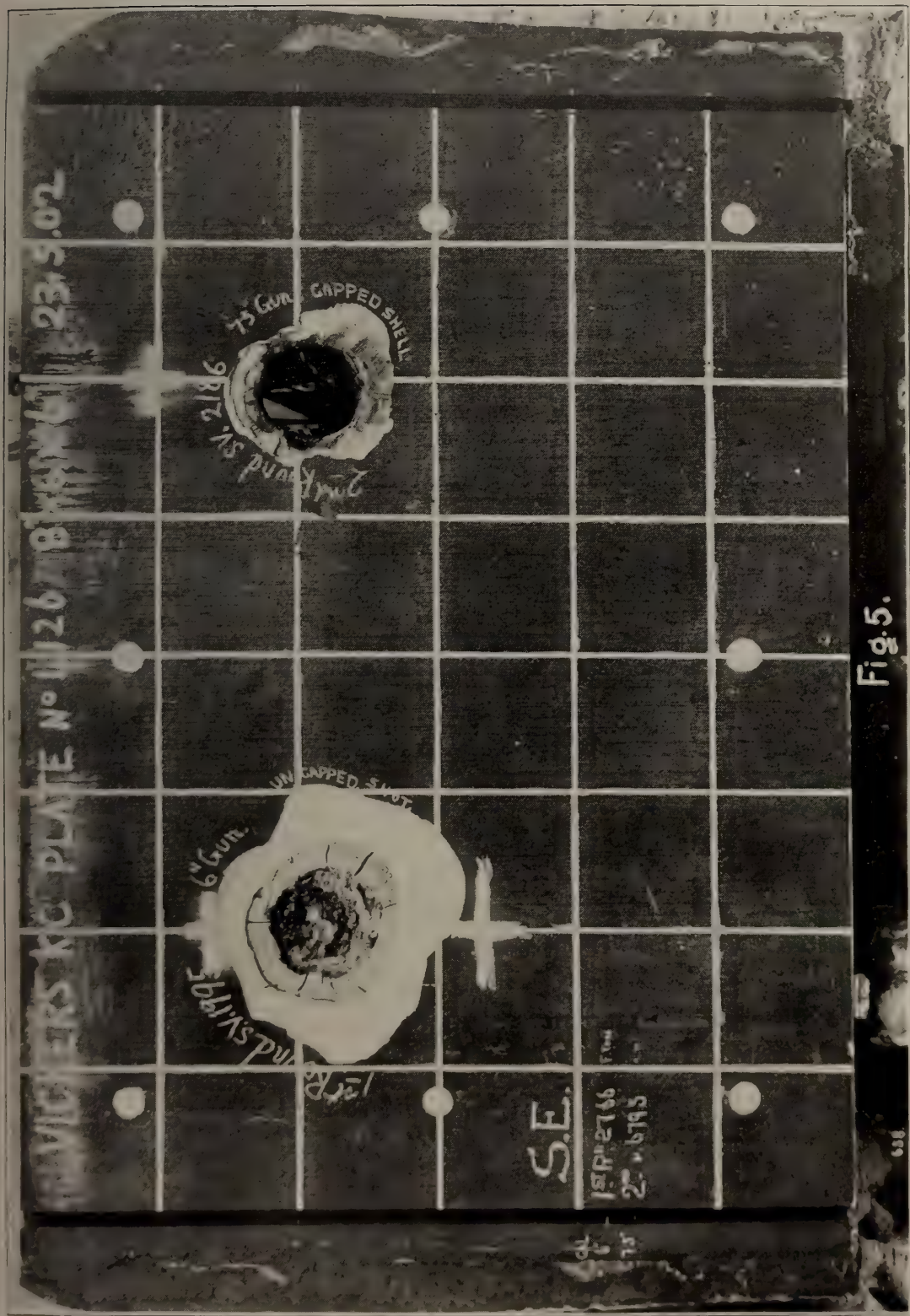


Fig. 4.

TESTS OF 6-INCH AND 7.5-INCH CAPPED AND UNCAPPED PROJECTILES AGAINST 6-INCH (K. C.) PLATE.



TESTS OF 6-INCH AND 7.5-INCH CAPPED AND UNCAPPED PROJECTILES AGAINST 6-INCH (K. C.) PLATE.

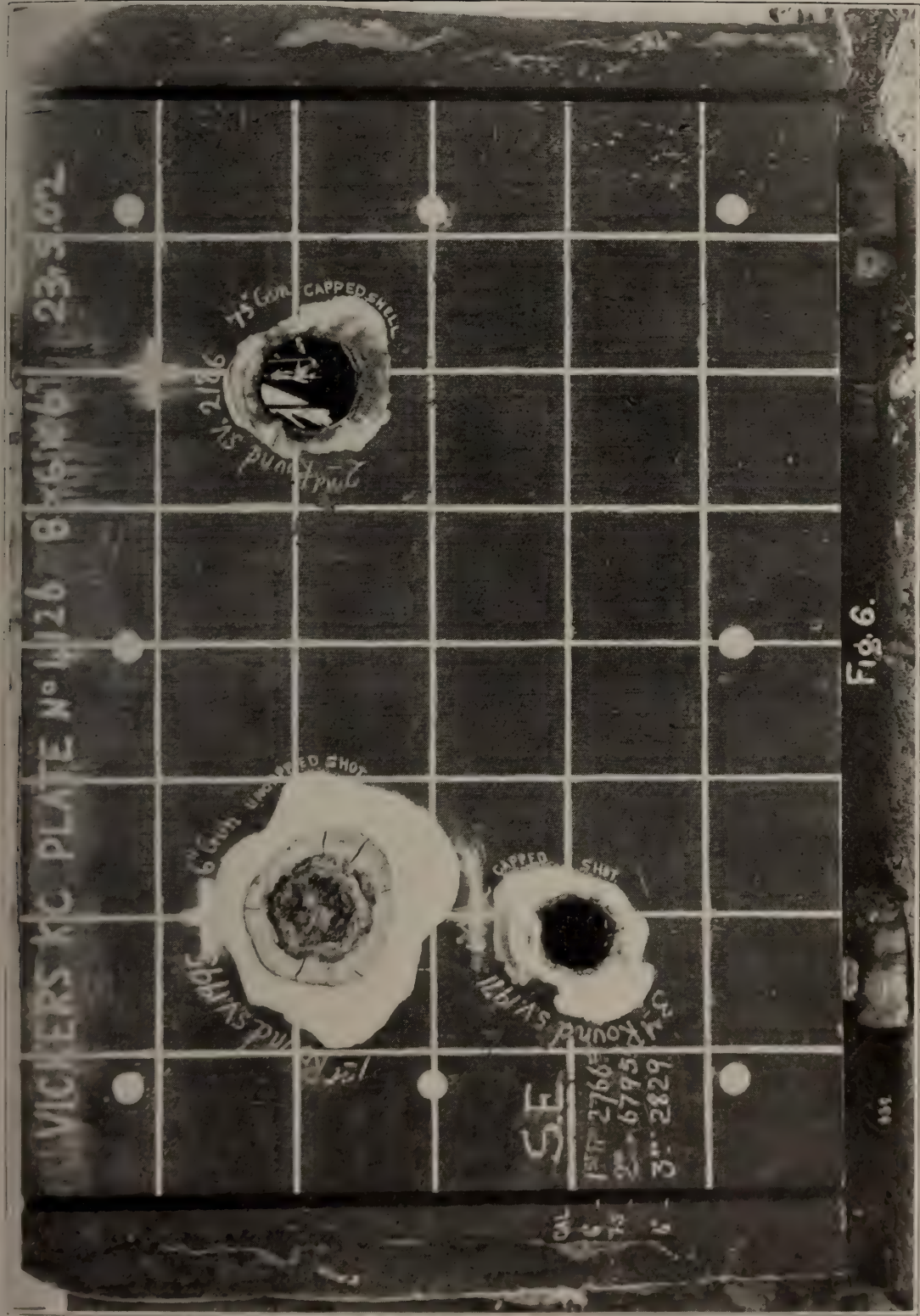


Fig. 6.

TESTS OF 6-INCH AND 7.5-INCH CAPPED AND UNCAPPED PROJECTILES AGAINST 6-INCH (K. C.) PLATE.

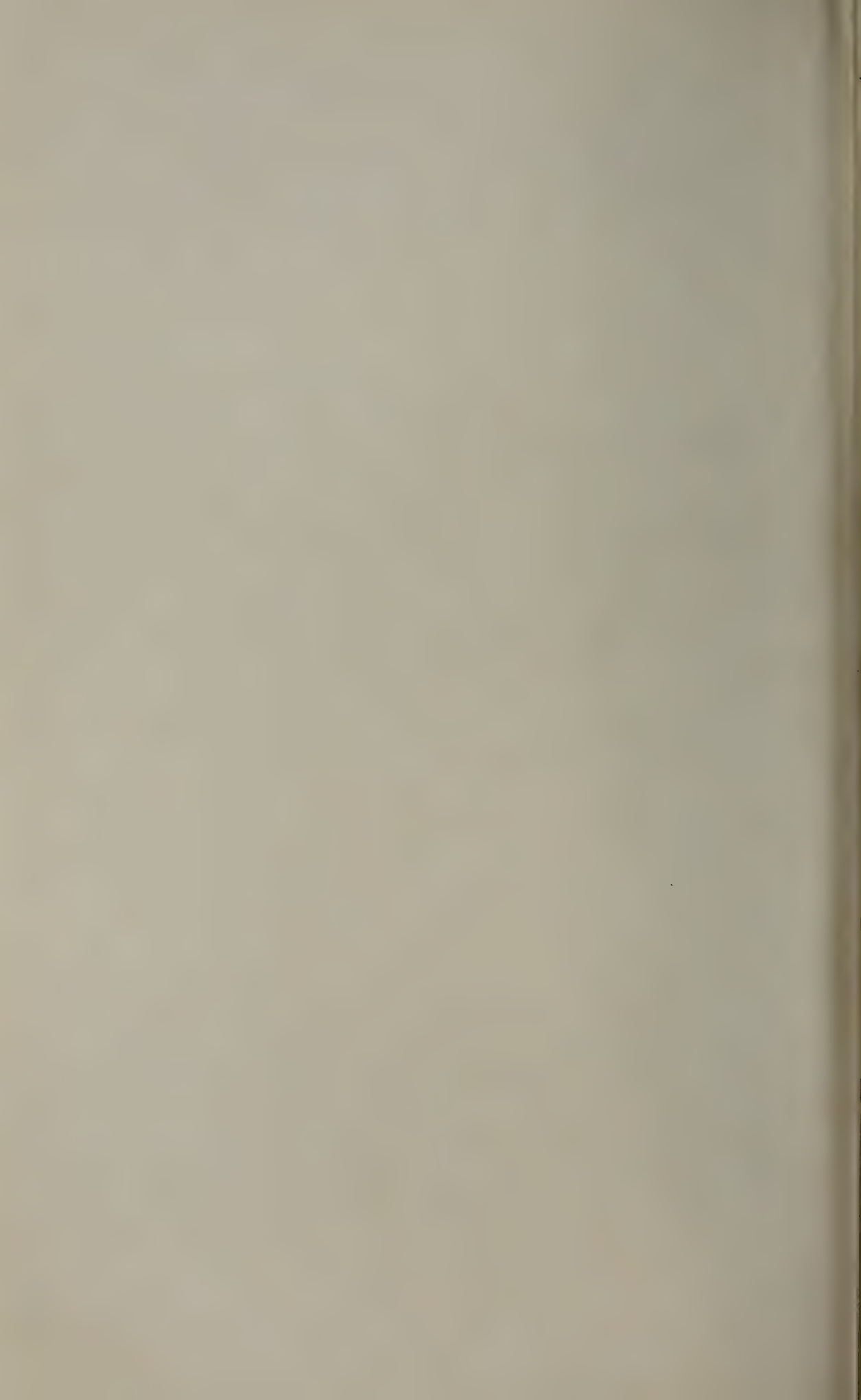


TABLE II (see figs. 2 and 3).—Fourth and fifth rounds against 11½-inch plate.

Date: May 23, 1902. Firing at Eskmeals range for trial of Vickers 6-inch armor-piercing shot fitted with Johnson cap against a Vickers 12-inch K. C. plate, No. 4865. Ordnance: No. 1037A, 6-inch, Mark B. Mounting: Naval pedestal.

Round.	Charge.		Projectile and fuze.	Mean muzzle velocity.	Temperature of charge, 80° F. Thermometer { Dry bulb, 55° F. Wet bulb, 54° F. Barometer, 30.3 inches.		
	Nature.	Weight.			Striking velocity.	Striking energy.	Ramming.
		Pounds.		Foot-sec.	Foot-sec.	Foot-tons.	Inches.
4.....	R. R. 384. Nitro-cellulose.	34	6-in. Vickers A. P. shot fitted with Johnson cap. Weight, 105.5 lb.	2,841	2,786	5,676	41.75
5.....	do.....	34	6-in. standard A. P. shot without cap. Weight, 100 lb.	2,887	2,827	5,542	41.7

Three rounds had previously been fired at this plate on May 9, 1902.

Round 4.—Shot completely perforated plate, but did not get through the wood backing or skin plate. The shot remained in backing, the rear of base being 9 inches from surface of plate; a feeler could be inserted along the outside of shot to a distance of 16 inches from surface of plate. The extent of injury by scalding was 20 inches H. by 22½ inches V.

Round 5.—Shot completely broken up. Penetration 3 inches. Point of shot remained fuzed in plate. A large piece of shot rebounded and was found 20 feet in front of plate.

TABLE III (see figs. 4, 5, and 6).—Trials against the 6-inch plate.

Date: May 23, 1902. Firing at Eskmeals range for trial of Vickers 6-inch armor-piercing shot and 7.5-inch armor-piercing shell, both fitted with Johnson caps, against a Vickers K. C. plate, No. 4126, 8 feet by 6 feet by 6 inches. Ordnance: No. 1037A, 6-inch, Mark B, and No. 1017A, 7.5-inch, 50 calibers. Mounting: Naval pedestal.

Round.	Charge.		Projectile and fuze.	Mean muzzle velocity.	Temperature of charge, 80° F. Thermometer { Dry bulb, 55° F. Wet bulb, 54° F. Barometer, 30.3 inches.		
	Nature.	Weight.			Striking velocity.	Striking energy.	Ramming.
		Pounds.		Foot-sec.	Foot-sec.	Foot-tons.	Inches.
1.....	Cordite ²⁰ / ₁₇ lot 119.	12.5	6-in. A. P. shot (Vickers), without cap. Weight, 100 lb.	2,034	1,995	2,766	41.25
2.....	Cordite ³⁰ / ₃₀ lot 117.	35.3125	7.5 in. A. P. shell, fitted with Johnson cap. Weight, 205 lb.	2,221	2,186	6,795	66.75
3.....	Cordite ²⁰ / ₁₇ lot 119.	12.94	6-in. A. P. shot (Vickers), fitted with Johnson cap. Weight, 105 lb.	2,007	1,971	2,829	41.31

Round 1.—Projectile broke up, point remaining fuzed in plate. Extent of injury by scalding, 24 inches H. by 22 inches V. There were no cracks. There were signs of a bulge at the back.

Round 2.—Complete perforation took place; no pieces of shell, except the base plug, were found. The size of hole was 8.75 inches by 8.5 inches. Extent of scalding, 14.5 inches H. by 14.5 inches V. The point of shell of this round, weighing 92 pounds, was subsequently recovered, having penetrated 20 feet into sand at rear of target.

Round 3.—Complete perforation took place. Projectile broke up, pieces being found in rear. Size of hole, about 6½ inches. Extent of injury by scalding was 13 inches H. by 14 inches V.

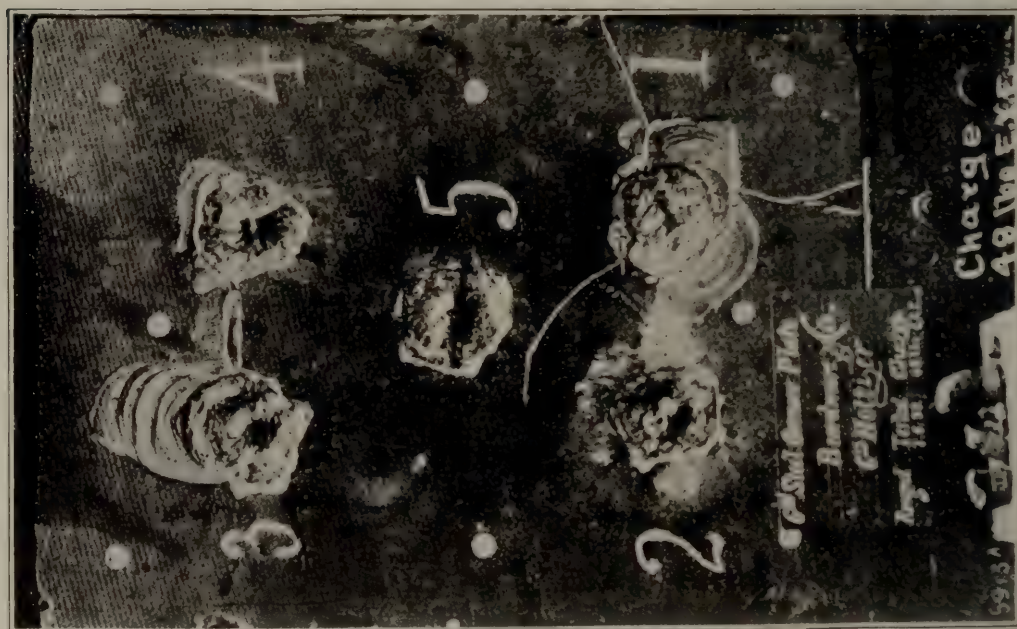
A series of five rounds was then fired from the 7.5-inch gun at a target 1,000 yards off. Starting with the gun loaded, the time to pressing trigger for fifth round was thirty-one seconds. All the rounds hit within a space about 6 feet H. by 5 feet V.

TESTS OF BEARDMORE ARMOR PLATES.

Messrs. William Beardmore & Co., Glasgow, half of whose shares have been purchased by Messrs. Vickers, Sons & Maxim, Limited, have perfected a process for hardening armor plate which has given splendid results in recent tests. The engravings reproduced are from photographs taken of the front and back of 6-inch plates, the one tested in the early days of the process, and the other a few months ago, specially to determine the limits of resistance.

The earlier plate, shown by figs. 1 and 2, was attacked by a 6-inch breech-loading gun firing Holtzer projectiles with a charge of 48 pounds of E X E powder, the pressure varying between 15.2 and 15.5 tons. The backing was 4 feet 10 inches at top and bottom and 5 feet 10 inches in the center, and was secured by 8 bolts. It will be seen from the tabulated results that the crack showing on fig. 1, from the bottom to the indent made by the first shot, was the result of the second round, and that the third round caused a crack from the point where the first shot struck to the right edge of the plate, the same cracks being developed in the succeeding rounds; but otherwise the plate stood well, all of the projectiles being broken up.

The plate tried quite recently—8 feet 6 inches by 6 feet 6 inches—gave splendid results. It was made according to Beardmore's latest process, was 6 inches thick, and was attacked by a Vickers 6-inch gun, with increasing charges, the idea being to ascertain how much the plate could stand. The arrangement of the backing is clearly shown in fig. 10. The first round, with a striking energy of 2,764 foot-tons, was broken up. The second round had no effect, while the third shot, of 2,912 foot-tons, was similarly broken up, the point remaining fused in the plate. The fourth shot, at 3,280 foot-tons, got further home, the penetration being about 3 inches, as compared with 2 inches in the previous round; and while the fifth round, at the exceptionally high energy of 3,550 foot-tons, got through the plate, it had all its energy spent, as the nose of the projectile is barely discernible through the back skin of the plate. No crack was made, so that the plate may almost be pronounced as invulnerable in ordinary conditions of warfare.

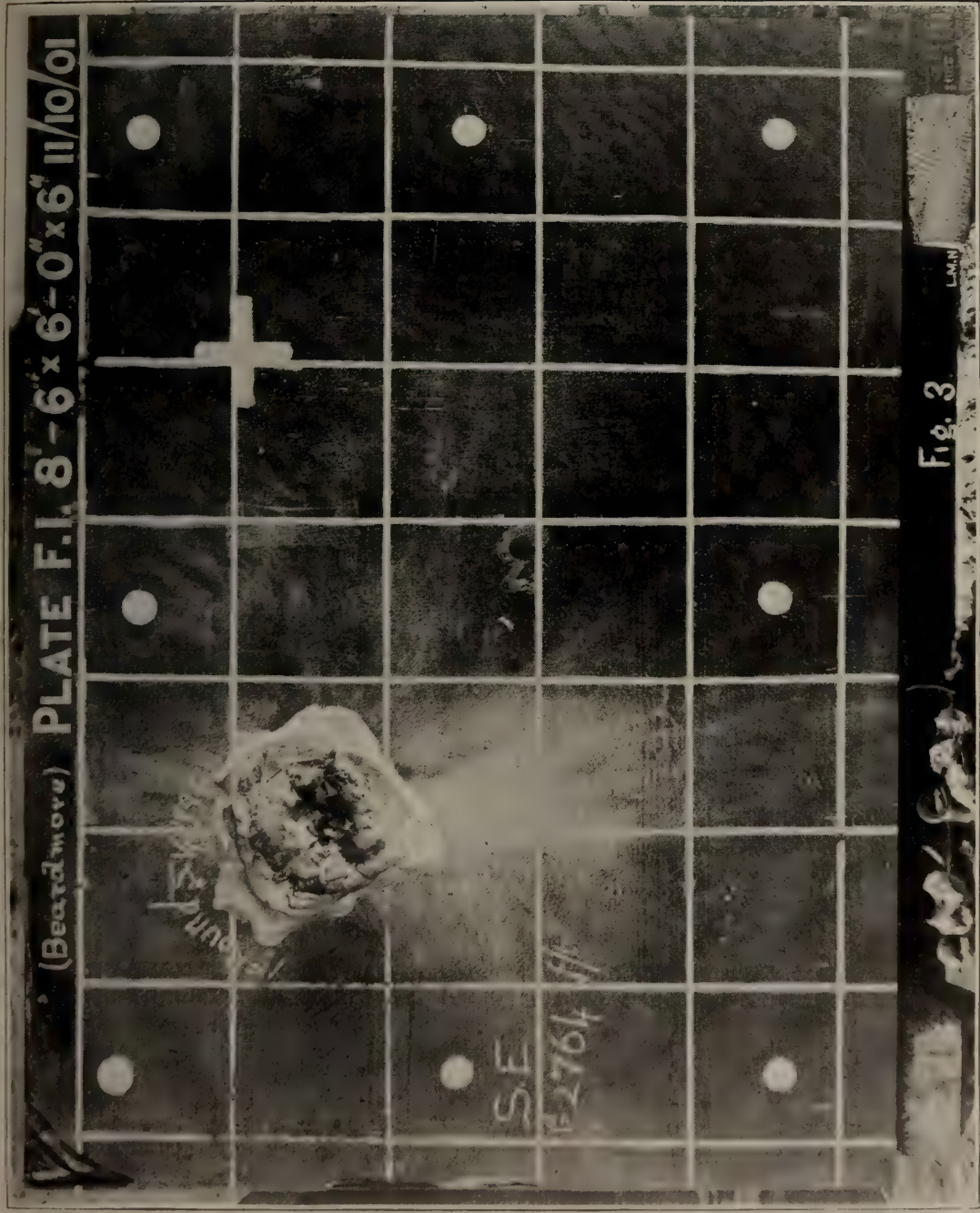


FIGS. 1, 2.—6-INCH BEARDMORE PLATE TRIED BY THE ADMIRALTY ON BOARD THE NETTLE.

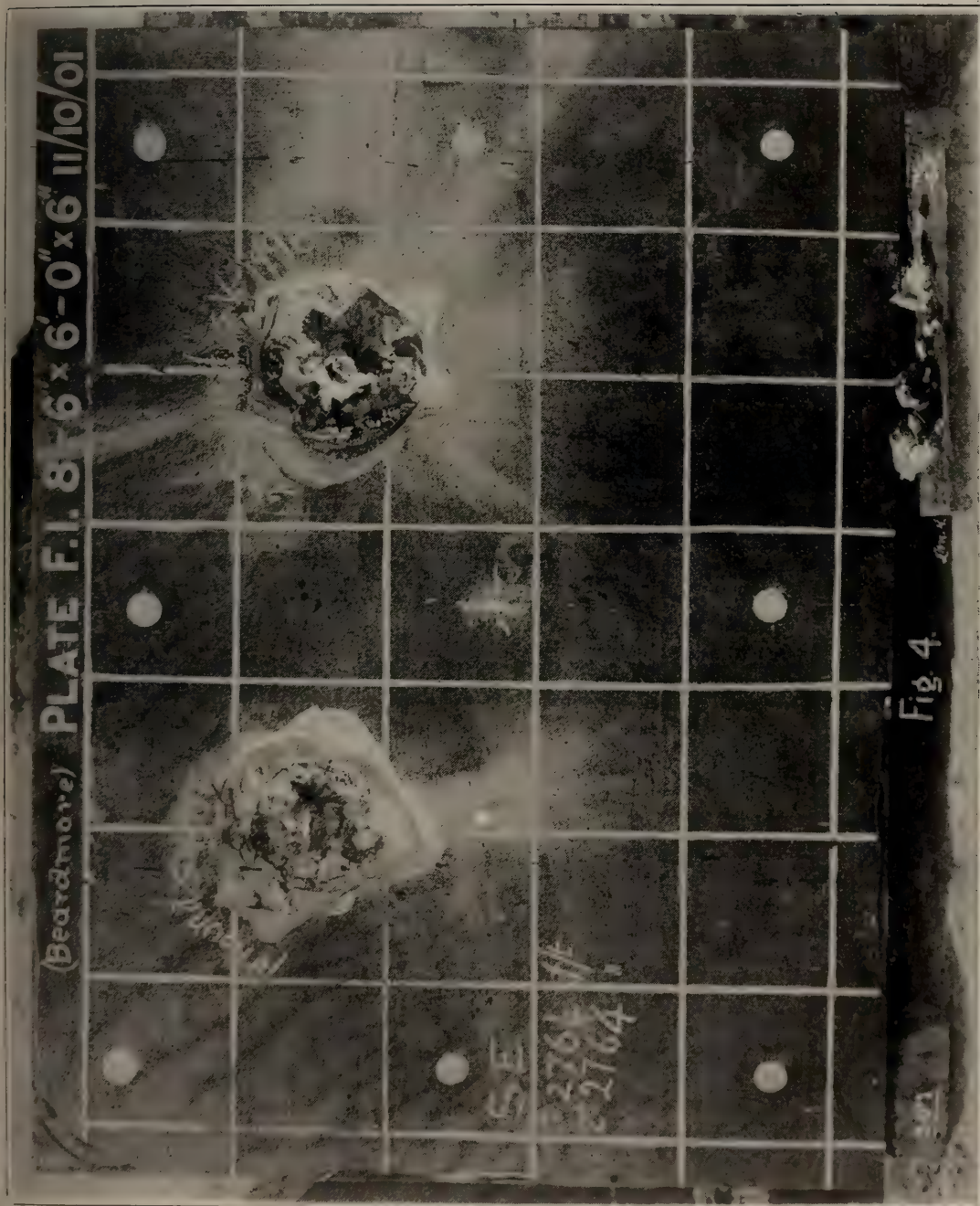
Round.	Elevation of gun.	Pres-sures.	Point of striking.	Effect on front of plate.	Result on back plate.	Effect of striking on projectile.	Temperature of air.
1.....	30 0	Tons. 15.5	2 ft. from right edge and 2 ft. from bottom.	Penetration: Displacement of plate, 13 in. by 13 in., partly drawn back; depth of indentation, $\frac{1}{2}$ in.; plate driven back locally: size of injury, 2 ft. by 1 ft. 8 in.	Plate: Size of bulge, 13 in. by $13\frac{1}{2}$ in.; height, $1\frac{1}{2}$ in. Backing: Size of indent, $17\frac{1}{2}$ in. by $13\frac{1}{2}$ in.; depth, $\frac{7}{8}$ in.	Projectile broken up into 3 large pieces and several small ones.	Temperature of mag., 59°; air, 61°.
2.....	25 0	15.4	2 ft. from left edge and 2 ft. from bottom.	Penetration: Size of injury, 12 in. by 12 in.; depth of point of core from face of plate, $\frac{3}{4}$ in.; plate cracked from bottom up to round 1: scales broken off left edge of plate.	Plate: Size of bulge, 13 in. by $13\frac{1}{2}$ in.; height, $1\frac{1}{2}$ in. Backing: Size of indent, $15\frac{1}{2}$ in. by 15 in.; depth, $1\frac{1}{2}$ in.	Projectile broken up into 4 large pieces and several small ones.	Powder.—Mk. I E X E. Lot 332; date, Jan. 8, 1895; mk. 1950. E. 2663.
3.....	5 30 E.	15.2	2 ft. from top and 2 ft. from left edge.	Penetration: Diameter of displacement, 13 in. by 13 in.; plate set back locally: depth from core to face of plate, 4 in.; plate cracked from right edge to injury of round 1; slight scaling of left edge of plate; diameter of injury, 24 in. by 15 in.	Plate: Size of bulge, $13\frac{1}{2}$ in. by 13 in.; height, $1\frac{1}{2}$ in. Backing: Size of indent, 13 in. by $13\frac{1}{2}$ in.; depth, $\frac{3}{4}$ in.	Projectile broken up.	
4.....	5 20 E.	15.25	2 ft. from top and 2 ft. from right edge.	Penetration: Point of core protruding from face of plate, 1 in.; diameter of displacement, 12 in. by 12 in.; size of injury, 25 in. by 12 in.; crack of round 1 further developed.	Plate: Size of bulge, $13\frac{1}{2}$ in. by 13 in.; height, $1\frac{1}{2}$ in. Backing: Size of indent, 12 in. by 13 in.; depth, $\frac{3}{4}$ in.	Projectile broken up into 4 large pieces and several small ones.	
5.....	2 30 E.	15.25	3 ft. from side, 4 ft. from top or bottom.	Penetration: Diameter of injury, 14 in. by 14 in.; point of core protruding from face of plate, $1\frac{1}{4}$ in.; plate cracked slightly between rounds 1 and 2. and also a circumferential crack at top of round 2.	Plate: Size of bulge, 12 in. by $12\frac{1}{2}$ in.; height, $1\frac{3}{8}$ in. Backing: Size of indent, $13\frac{1}{2}$ in. by 14 in.; depth, $\frac{3}{4}$ in.	Projectile broken up into 3 large pieces and several small ones.	

FIGS. 3-7.—BEARDMORE'S LATEST 6-INCH PLATE TESTED TO ASCERTAIN LIMITS OF RESISTANCE.
Attacked by Vickers's 6-inch gun with Elswick A. P. shot (100 pounds) fitted with cordite driving band.

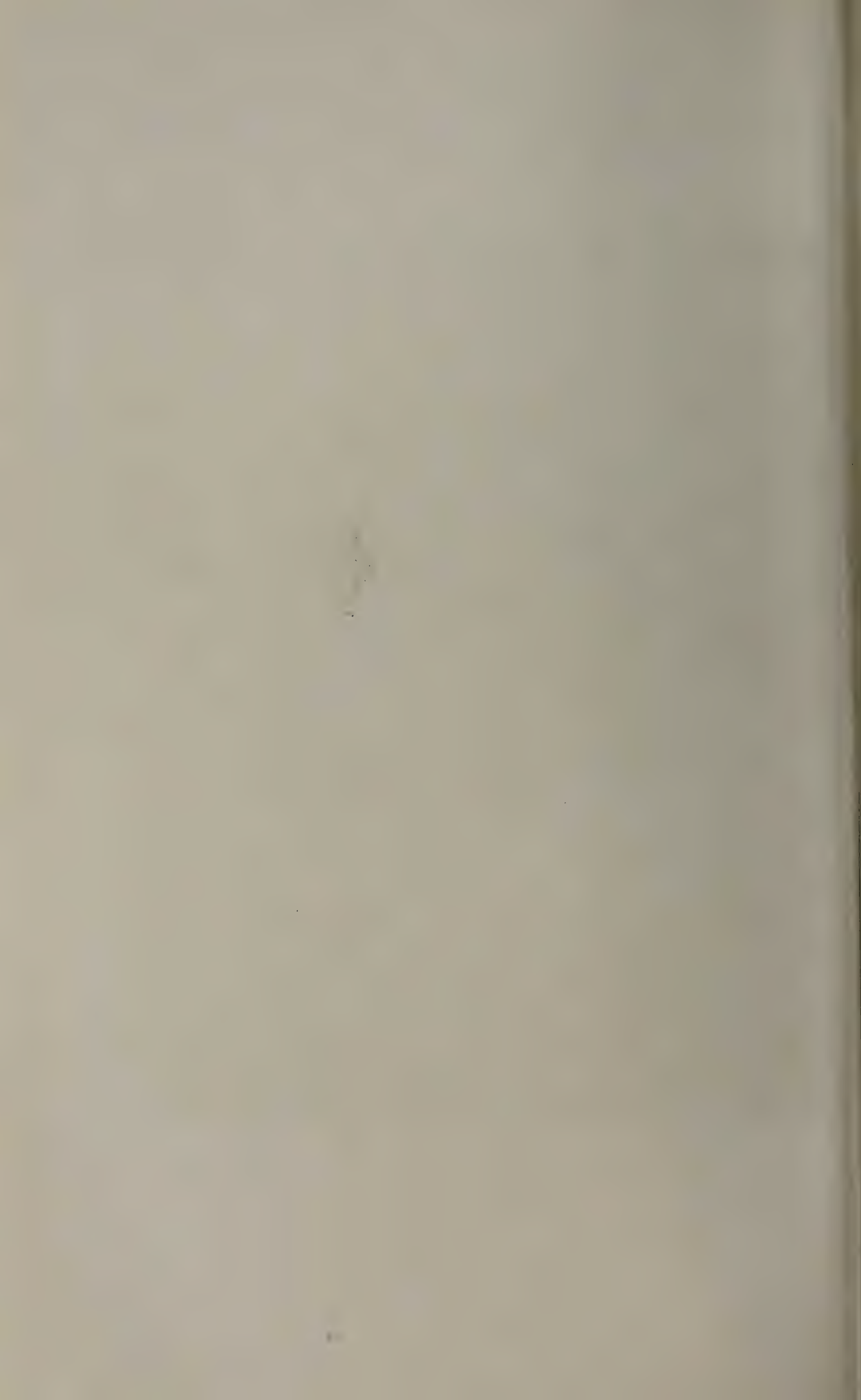
Round.	Cordite charge, weight.	Striking velocity.	Striking energy.	By Tresidder's formula.		Effect.
				Penetration, wrought iron.	Figure of merit.	
	<i>Lbs. Oz.</i>	<i>Foot-seconds.</i>	<i>Foot-tons.</i>			
1.....	13 10	1,996	2,764	13.8	2.3	Projectile completely broken up. Point left fused in plate. Slight scaling round point of impact, the extent of which was 20 in. horizontal measurement and 18 in. vertical measurement. No cracks.
2.....	13 10	1,996	2,764	13.8	2.3	The velocity obtained was identical with first round, and the effect on the plate was the same. The projectile was completely broken up. There were no cracks. The extent of injury by scaling was 17 in. horizontal measurement and 17 in. vertical measurement. It was then decided to increase the charge, and round 3 was fired.
3.....	14 8	2,049	2,912	14.6	2.4	The effect of this round on the plate was very similar. The projectile was completely broken up, the point remaining fused in the plate. The extent of injury by scaling was 19 in. horizontal and 19 in. vertical measurement. It was then decided to increase the charge again, and round 4 was fired.
4.....	16 16	2,177	3,280	15.7	2.61	This time there was rather more penetration, this being, as far as could be measured, about 3 in. against 2 in. in previous round. The projectile was completely broken up again, and the point remained fused in the plate. The extent of injury by scaling was 22 in. horizontal and 15 in. vertical. There were no cracks. After round 4 was fired, it was decided to fire with a considerably increased velocity to try and ascertain the limits of resistance of the plate.
5.....	16 13½	2,261	3,550	16.6	2.77	This round completely perforated the plate, but the projectile, after perforation, had apparently lost all its energy, as although it just broke the skin-plate at the back, it failed to pass through it, and the whole of the front part of the projectile could be seen lying between the skin-plate and the wood backing. The extent of injury by scaling was measured as 22½ in. vertical and 16 in. horizontal. After this round, surface cracks were found on the plate extending from the point of impact of round 1 to that of round 2. Also another from point of impact of round 1 to the top of the plate—one going approximately to the center of the plate, and the other to 18 in. from the left top corner; also from round 1 to left edge of plate and from round 5 to lower edge of plate, and from round 3 to lower edge of plate. These were surface cracks.

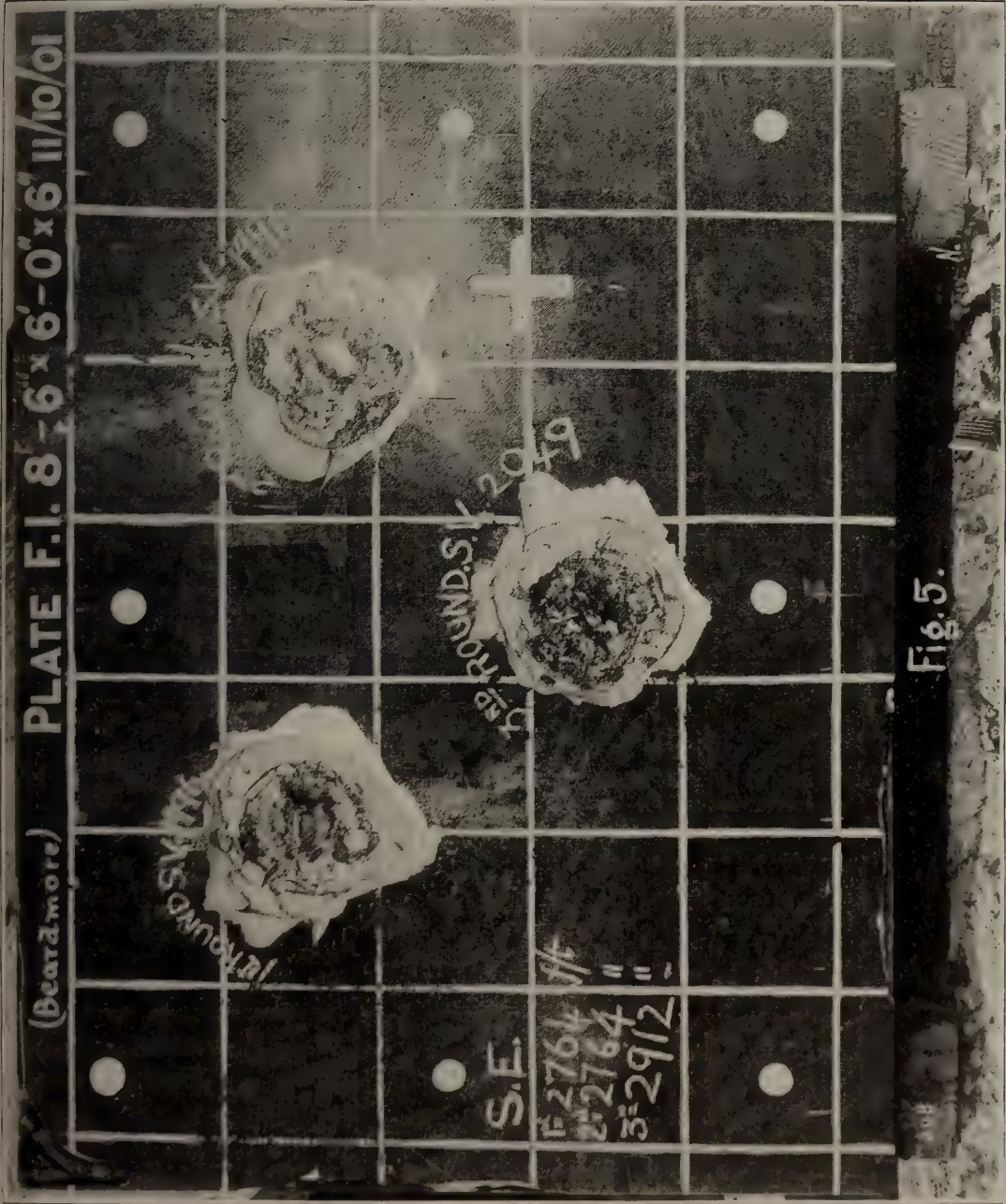


TESTS OF LATEST BEARDMORE 6-INCH PLATE.



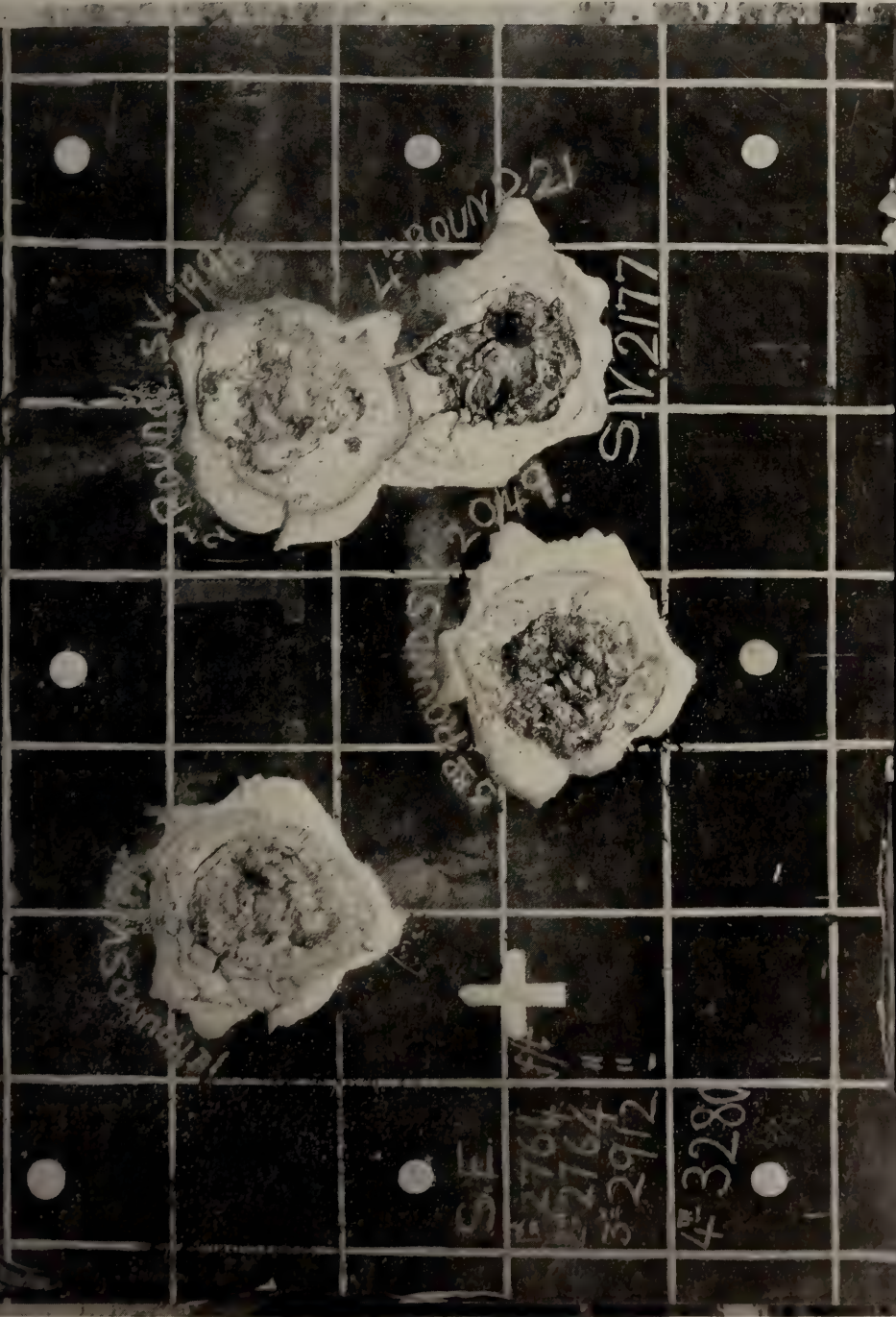
TESTS OF LATEST BEARDMORE 6-INCH PLATE.



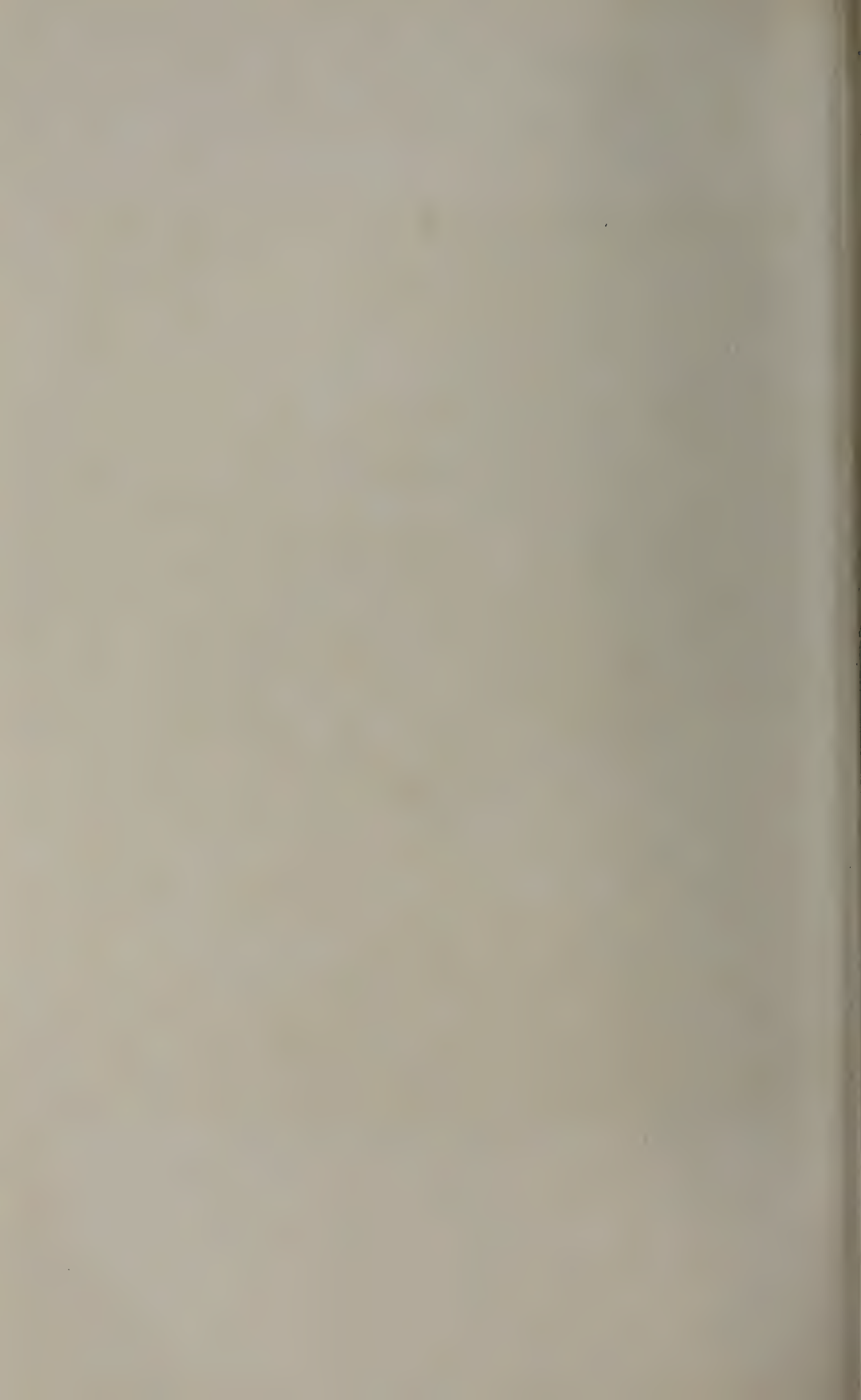


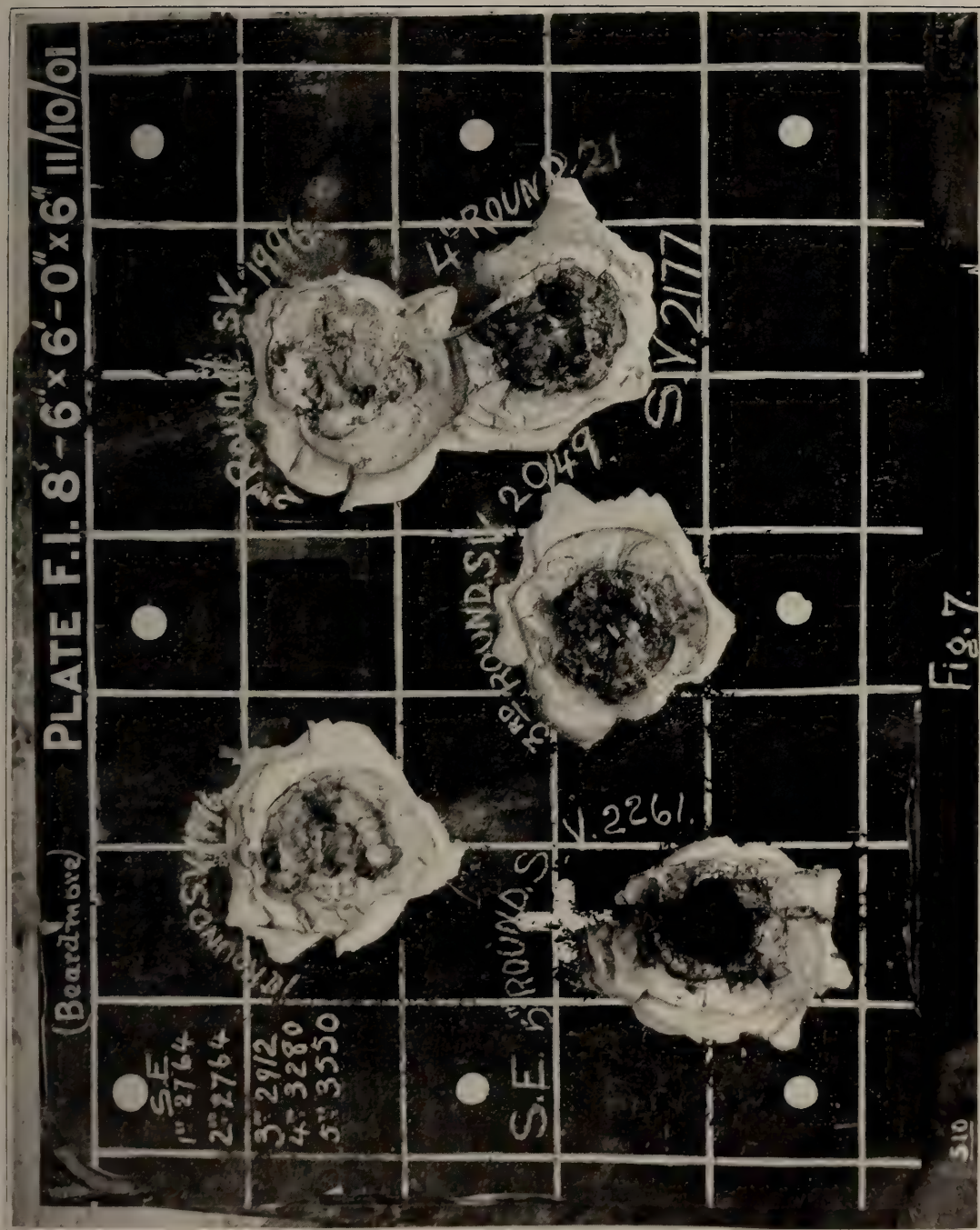
TESTS OF LATEST BEARDMORE 6-INCH PLATE.

(Beardmore) PLATE F.I. 8-6 x 6'-0" x 6" 11/10/01



TESTS OF LATEST BEARDMORE 6-INCH PLATE.

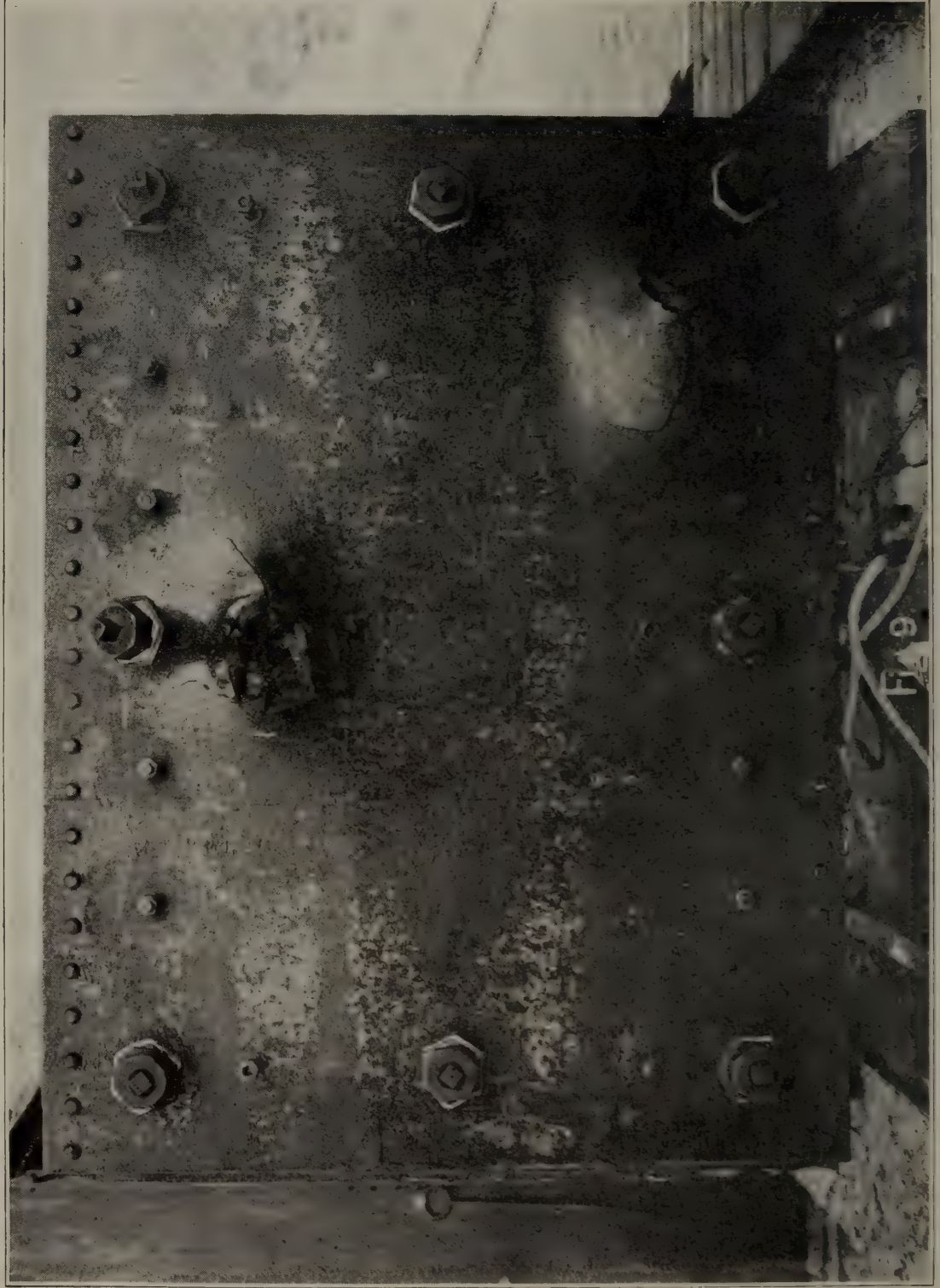




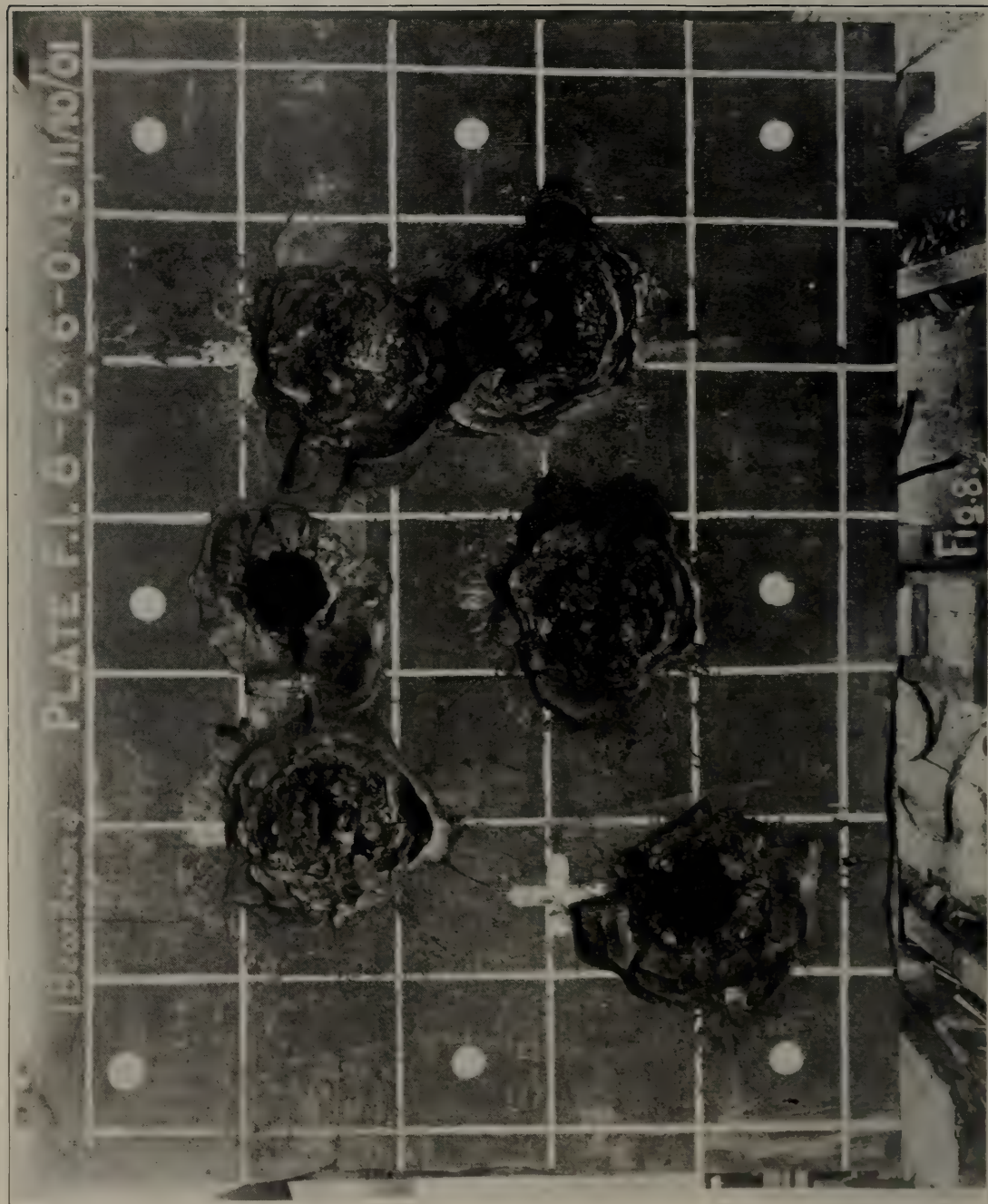
TESTS OF LATEST BEARDMORE 6-INCH PLATE.



TESTS OF LATEST BEARDMORE 6-INCH PLATE.



TESTS OF LATEST BEARDMORE 6-INCH PLATE.



TESTS OF LATEST BEARDMORE 6-INCH PLATE.



FIG. 11.—ELSWICK A. P. SHOT AFTER PASSING THROUGH BEARDMORE 6-INCH PLATE.

Two months after the above test a sixth round was fired at this plate to test the Johnson cap for projectiles. The projectile made a clean hole, passed through the backing and skin, and buried itself in the sand butt. When found, immediately afterwards, it was quite cool.

See figs. 8 to 11.

Elements of test of Johnson cap. Beardsmore 6-inch plate.

Number of round.....	6
Weight of projectile.....	pounds.. 105.9
Striking velocity.....	foot-seconds.. 1,945
Striking energy.....	foot-tons.. 2,778
Penetration.....	Through

REMARKS.—Johnson steel A. P. shell fitted with Johnson cap. Charge, cordite. 13 pounds 4 ounces.

TRIAL OF ARMOR FOR H. M. S. "VENERABLE."

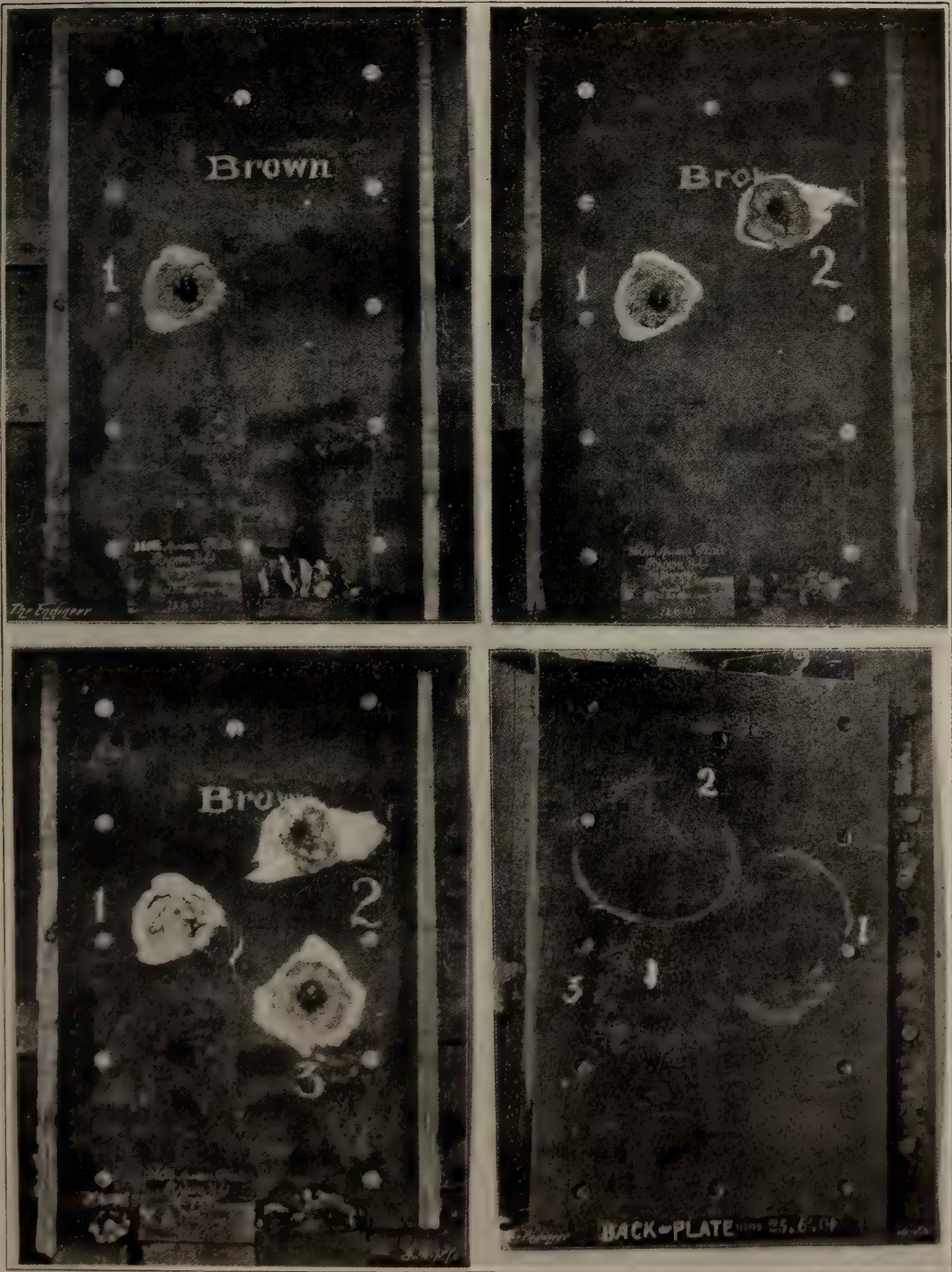
[The Engineer.]

On July 25, 1901, at the Admiralty proving ranges, at Whale Island, Portsmouth, there was carried out the first of a series of armor-plate trials of more than ordinary importance. The British system of Admiralty control over armor-plate manufacture is, for each order or series of orders, to subject to a firing test a preliminary sample plate, made under the direct supervision of the Admiralty overseers, and, if this sample is satisfactory, to order a number of plates to be made like it, also under direct supervision. The advantage of this system is that the Government officials have and fully exercise the right to watch and check the manufacture in all its details and at all its stages. Most foreign governments, however, employ a different system. They do not control the details of manufacture, but select a plate in a more or less finished state from the plates in progress, and, assuming that plate to represent the whole, subject it to a firing test, on the results of which the fate of all the plates concerned depends. It will be seen that each system has its advantages; and while it would not be reasonable to employ both at the same time, the maximum guaranty of efficiency may be obtained by the occasional use of the foreign system to check our own. It is from being the first example of the carrying out of this check, which the Admiralty, however, have always reserved the right to exercise, that the trial referred to derives its importance. The plate tested was one that had been made by John Brown & Co., Limited, and fitted to its neighbors as part of the belt armor of H. M. S. *Venerable*. It had been completed in every respect and, except the drilling of the bolt holes in the back, was ready to be attached to the ship's side. But there were some defects in the nature of cracks at one end, concerning the importance of which the Admiralty overseer had some doubts, and the Admiralty, on this being reported to them, decided to select this plate for a check-firing trial.

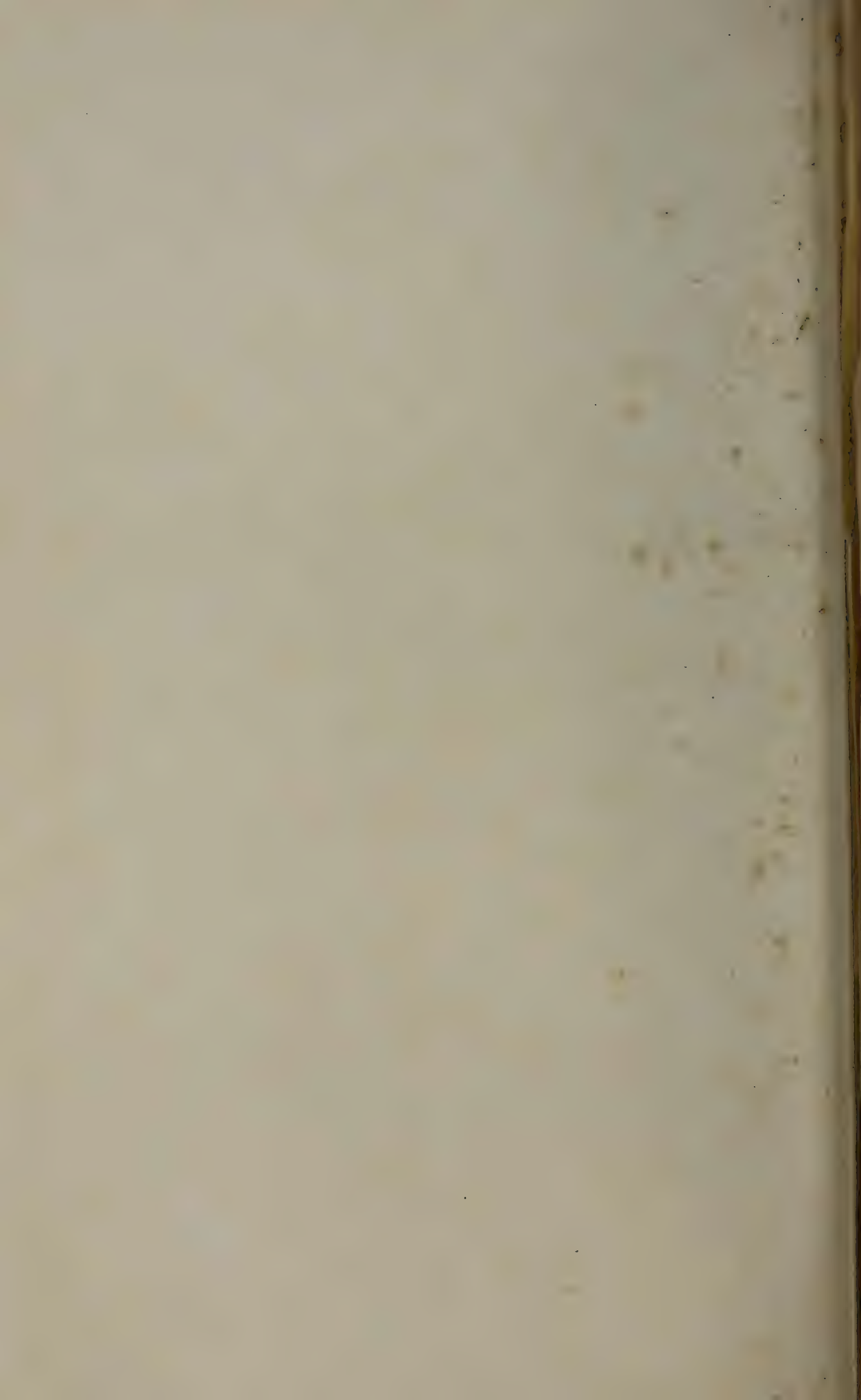
As far as could be judged, then, from all appearances, its quality was below rather than above the average for the whole ship. The face of the plate had drilled and tapped in it about 90 small holes for various attachments, so that some little difficulty was experienced in arranging the points to be fired at—the apices of a triangle of 3 feet each side—to prevent either of them actually falling upon one of these small holes. According to the Admiralty specification, the plate had to resist two blows from the 9.2-inch armor-piercing steel shot of 380 pounds weight, striking with a velocity of 1,900 foot-seconds, and one blow of the same shot with such reduced velocity as the plate seemed then capable of sustaining. As a fact, this plate stood the first two rounds so well that the third was also fired with the full velocity. One crack to the edge, there 4 inches deep, was occasioned, as well as a few superficial hair cracks in the face; but all the projectiles were smashed to pieces without attaining more than $3\frac{1}{2}$ inches of penetration. The following are the particulars of the trial: Plate, 12 feet by 7 feet 6 inches by 8.8 inches thick, bent and fitted to ship's side; bolts, twelve of $4\frac{1}{8}$ -inch diameter, 5 feet long; backing, oak; frame, none; attack, three rounds of Holtzer armor-piercing steel projectiles of 9.2-inch diameter, and 381 pounds, 379 pounds, and 379 pounds weight striking at the apices of an equilateral triangle 3 feet per side, with velocities respectively of 1,899, 1,900, and 1,900 foot-seconds, each capable of piercing over 20 inches of wrought iron.

A sample armor plate, selected at random from a number of plates, manufactured by Messrs. Cammell & Co., of Sheffield, for the battleship *Bulwark*, was tested at Whale Island under the usual Admiralty conditions. The plate was nominally of 9 inches thickness, but the exact measurement was 8.8 inches, and the length and breadth were 14 feet by 6 feet 10 inches, and the weight of metal was 360 pounds to the square foot. Three Holtzer armor-piercing shot, each weighing 380 pounds, were fired at the plate from the 9.2-inch B. L. gun, and the plate resisted the attack in such a manner as to satisfy the conditions imposed by the Admiralty. Each shell was broken into fragments, the penetration being almost nil, and while there were no cracks, there was a slight flaking of the plate at the point of impact. The nose of one projectile became embedded in the plate, but it did not travel beyond the hardened surface. The velocity of the projectiles was about 1,900 foot-seconds.

Sample plates of 4-inch noncemented quality of armor submitted by Sir W. G. Armstrong, Whitworth & Co., Openshaw Works, Manchester, as specimens of armor for the cruiser *Lancaster*, were tested at Whale Island. The plates measured 4 feet by 4 feet, and each was



TRIAL OF ARMOR FOR H. M. S. VENERABLE.



required to stand three rounds of armor-piercing projectiles from the 4.7-inch Q. F. gun, fired with a striking velocity of 1,635 foot-seconds. The results of the tests showed that the service requirements were satisfied in every respect, the order for the armor being conditional upon the satisfactory tests of three plates. Five plates were tested, from which the necessary standards for guidance in manufacture of the armor for the above ship were selected. The average penetration was under 1 inch, and no crack or bulges were developed on the backs of the plates, which were in the same state as before firing.

At Whale Island a sample 2-inch plate manufactured by Messrs. Cammell & Co., of Sheffield, of the type used in gun shields and in continuation of the armor of battleships and armored cruisers from the belt to the ram was tested under the usual conditions. Three rounds were fired from a 6-pounder Q. F. gun, and each shot, which was fired at a velocity of 1,700 foot-seconds, splashed on the plate, but there was neither crack nor penetration. The plate was then subjected to a more severe test, one round being fired from a 4-inch Q. F. gun at a velocity of 1,650 foot-seconds. Again the shot splashed on the surface, causing neither crack nor penetration, but it set up a slight bulge, which indicated a satisfactory degree of elasticity. The whole of the armor of the battleship *Queen* is being manufactured by Messrs. Cammell & Co.

RESISTANCE OF SNOW WALL TO RIFLE BULLETS.

Experiments in Norway show that a wall of snow 4 feet thick, the snow being neither rammed nor frozen, was proof, at 50 yards distance, against the bullet of the Krag-Jørgensen rifle. The Norwegian rifle, 6.5 millimeters caliber, velocity 2,360 foot-seconds, is sighted up to 2,500 yards.

A NEW KRUPP ARMOR.

In reply to comments by The Engineer (London) in which criticism was made of the impossibility of applying the Krupp cemented process to plates of the inverted conical turret bases of German armored cruisers, Herr Krupp replied that the problem had been solved and that non-cemented plates for curved surfaces, with loss of resisting power, would be superseded by an entirely new process, giving plates "hardly inferior" to the cemented plate. The following description of this armor is from The Engineer of May 16, 1902:

For all curved surfaces, indeed, non-cemented Krupp is employed, with a corresponding loss of resisting efficiency. Herr Krupp's letter claimed that the problem had been solved. No details were entered into, and comment was therefore impossible.

We are now in a position to supply a few meager details of an entirely new armor process, which on trial has given a figure of merit as high as 2.8 without the limits of resistance being reached. The figure of merit of the best cemented Krupp vertical

plates varies from 2.7 to 3.1 or so, 3 being the generally accepted average. The variety that exists is due chiefly to the relative inexperience of some manufacturers and the fact that the lower efficiency plates were maiden efforts, or nearly so.

Few, if any, of Krupp's own plates have been tested beyond the resisting limit. Some figures of recent trials with cemented armor plates may be of interest, and they will serve to indicate how far tests have been carried against them.

Plate.	Highest penetration of shot against iron.	Minimum figure of merit.
5.5	15.7	2.85
4.5	11.4	2.53
11.8	33.6	2.85

These figures are from acceptance trials for plates for recent ships, and do not, therefore, imply anything beyond the fact that they were at least as good as the minimum given. The projectiles were broken, and the backs of the plates unhurt. Any of these, then, may be safely assumed at 3 as a figure of merit, the odds being rather that they would have exceeded that than otherwise. However, all this is by the way.

The new armor is claimed by Herr Krupp to be "hardly inferior" to cemented plate. Doubtless this claim is based upon comparative trials of the limits of resistance which are not public property. For that matter, nothing at all about the new armor has been public property for more than a few days, the plate exhibited by Herr Krupp at the Düsseldorf Exhibition, opened on the first of the present month, being the first "publication" of the matter, and this, we believe, the first reference to the matter in the British press.

The process is not, however, of immediate moment. The points of salient importance are that the armor is, for most practical purposes, equal to the best cemented; and (2) that it is believed to be applicable to any form or shape that may be required. Round turret cupolas have already been constructed of it, and are known to have undergone severe tests at Meppen—Herr Krupp's proving ground.

The appended photographs, figs. 1 and 2, show an exhibition plate of this armor which is now at Düsseldorf Exhibition. It was, in the first place, cast as a block 14 by 12½ by 3½ feet, and weighed 160 tons. It was rolled out and "cemented." The product was a show plate 48 by 11 feet and 11.8 inches thick, weighing 106 tons.

On April 2, 1902, a "casemate" plate of this cast-cemented armor was fired at at Meppen. The results were as follows:

Size of plate, 8½ by 6½ feet by 6 inches.

Shot.	Caliber of attack.	Weight of projectile, forged steel A. P. shell.	Striking velocity, foot-seconds.	Effect on projectile.	Effect on plate.
	<i>Inches.</i>	<i>Pounds.</i>			
I.....	6	112½	1,762	Broken up.....	No damage. 1.4-inch indentation.
II.....	6	112½	1,795	do.....	No damage. 2-inch indentation.
III.....	6	112½	1,840	do.....	No damage. 2.3-inch indentation.
IV.....	6	112½	1,860	do.....	Not penetrated.
V.....	6	112½	1,896	do.....	Do.

Shots II, III, and V indicate their presence on the back of the plate, which, it will be noted, has behaved much as an ordinary cement plate—exhibiting, if anything,

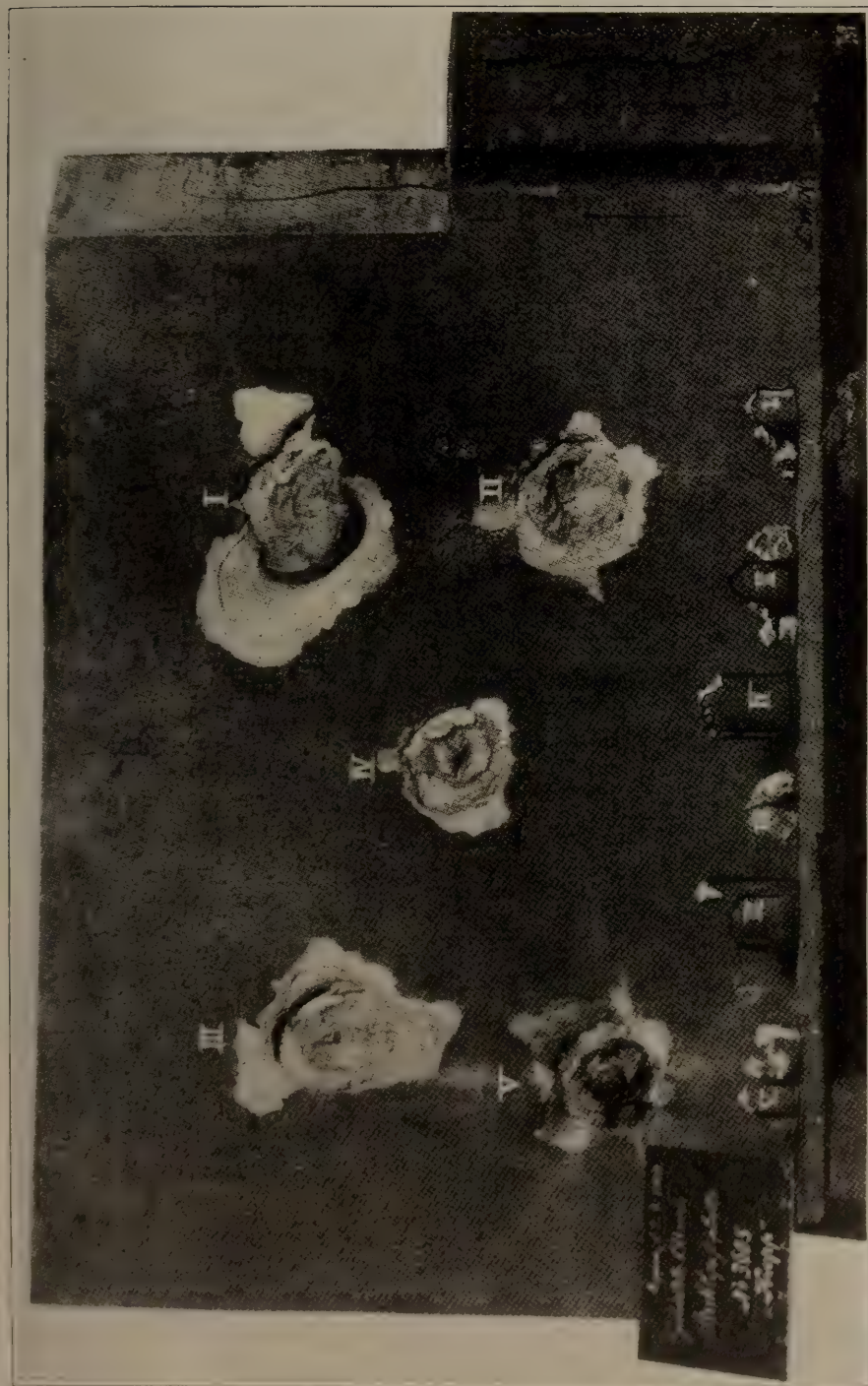


FIG. 1.—NEW KRUPP 6-INCH PLATE.

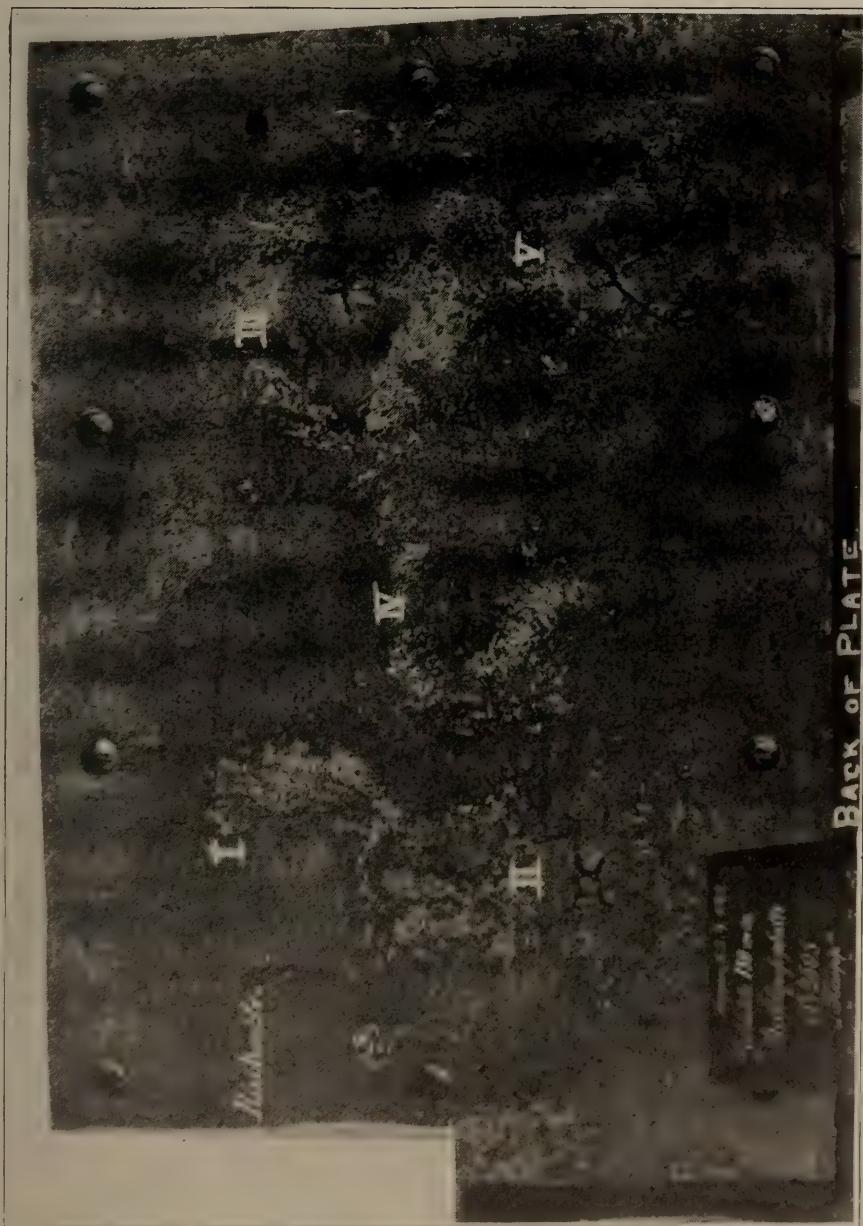
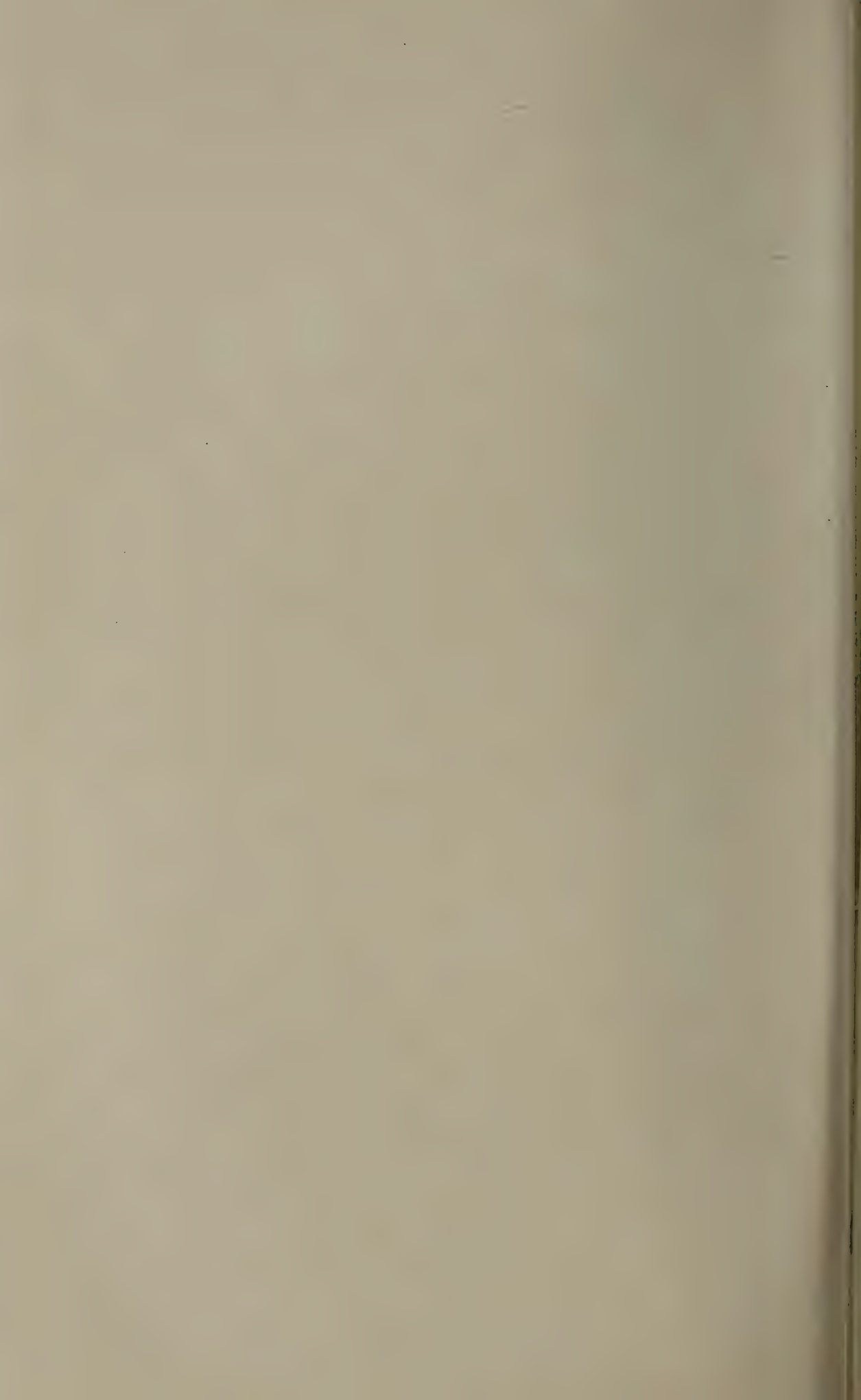


FIG. 2.—NEW KRUPP 6-INCH PLATE.



less tendency to crack under projectiles that nearly penetrated. Shot V, with 1,896 foot-seconds striking velocity, had a calculated penetration of 15-inch iron. The figure of merit of over 2.5 is established by this hit. Other trials, as we have stated, have shown a figure of merit of over 2.8.

The new armor exhibits great toughness, combined with a very hard face. In addition to other tests, it has stood that of a 10-inch shell loaded with nearly 65 pounds of high explosive picric acid, which is about equivalent to lyddite. An 8-inch cupola went through this test unharmed, and is now on exhibition at Düsseldorf.

The following interesting tables of comparison are reproduced from Brassey's Annual of 1902:

TABLE I.—Comparison of resistance of armor protecting main and secondary batteries in latest battleships.

Nation.	Name of ship.	Protection.			
		Secondary armament.		Main armament.	
		Actual thickness.	Equivalent in wrought iron.	Actual thickness.	Equivalent in wrought iron.
		<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
England.....	King Edward	7	18	12	28
France	République.....	6½ and 5½	17 and 14	11	26
Russia	Borodino	7	18	11	26
Germany	Wittelsbach	5½	14	10	24
United States.....	Georgia.....	6	16	11	26
Japan	Misaka	6	16	14	32
Average .....	.....		a 16		b 26

NOTE.—Proportion of (a) to (b), 1 to 1.6.

b Average without *Misaka*.

TABLE II.—Comparison of piercing power of main and secondary guns in latest battleships, 3,000 yards, using nitro-cellulose powders.

Ship.	Secondary armament piercing power, wrought iron, 3,000 yards.	Main armament piercing power, wrought iron, 3,000 yards.
King Edward	a 12 and 24	35
République	14	(?) 35
Borodino	12	(?) 35
Wittelsbach.....	12	32
Georgia	a 12 and 20	35
Misaka.....	12	35
Average.....	b 12½ and 22	c 34½

NOTE.—Proportion of (b) to (c), 1 to 2.7.

a Extra turret guns, 9.2 and 8 inches.

TABLE III.—Comparison of penetration, by 12-inch gun, of the heaviest armor of latest battleships.

	Inches.	Penetrable at ranges below by uncapped projectiles.			
		12-inch gun, present velocity.		12-inch gun with improved powder.	
		Direct.	30° to normal.	Direct.	30° to normal.
		Yards.	Yards.	Yards.	Yards.
Carnegie trial plate ^a	11.5	4,400	2,000	6,400	4,000
Thickest armor of—					
King Edward.....	12.0	4,000	1,600	6,000	3,600
République.....	11.0	5,000	2,500	7,000	4,600
Borodino	11.0	5,000	2,500	7,000	4,600
Wittlesbach	9.8	6,000	3,300	8,000	5,300
Vittorio Emanuel	9.8	6,000	3,300	8,000	5,300
Georgie.....	12.0	4,000	1,600	6,000	3,600

^a Pierced by 12-inch army gun in competition with Gathman gun at Sandy Hook.

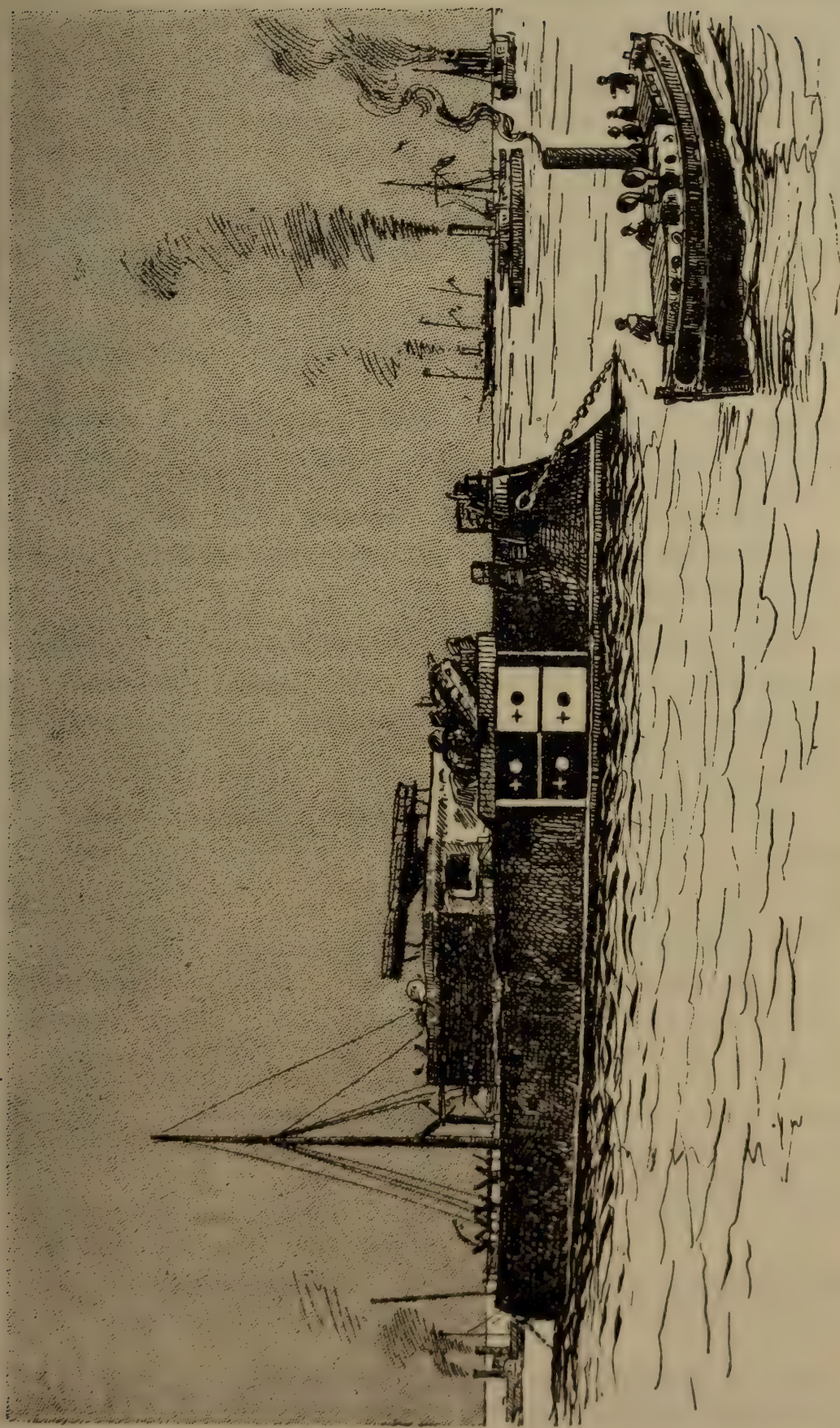
Commenting on the foregoing tables, and referring to a 12-inch gun with 2,800 foot-seconds (for 850 pound shell), Brassey says: "If the 11-inch and 12-inch plates are meant to act as safeguards against 12-inch projectiles, they are too thin; if simply required to keep out shot from Q. F. guns, they are unnecessarily thick."

THE BELLEISLE EXPERIMENTS OF 1902.

Last year the *Belleisle* was the subject of experiment to test the effect of modern shell fire on personnel and material. She carried coal, boats, stores, and dummies representing personnel at different stations, and was subjected to nine minutes' fire from a first-class battleship.

The supposed particular object of the foregoing experiment was to determine the effect of gun fire on woodwork. From the havoc wrought by this fire, the lesson of the *Belleisle* appeared to be that the efficiency of the personnel in rapidity and accuracy of fire is of first importance and will be the principal factor in the result; that naval battles of the future will be short engagements; and that the first accurate shot will greatly influence results. There also appeared the necessity for a greater distribution of armor, more protection for the ends of the vessels and for the personnel at the guns. The terrible concussion of lyddite and kindred high explosives seemed clearly demonstrated, as was the fact that batteries must be protected against the bursting of such shell inside their casemates. An account of this experiment appeared in General Information Series, No. XX, of July, 1901.

This year's tests were for the purpose of ascertaining the resistance presented by the sides and decks of the newest armored cruisers of the British navy, as well as the value of explosives, high and otherwise, as bursting charges in armor-piercing projectiles. To this end the hulk of the *Belleisle* was specially prepared. The account of the



THE "BELLE ISLE" PREPARED FOR THE GUNNERY EXPERIMENTS OF 1902.

experiments that has become public is very meager, the greatest effort to attain secrecy having been exerted by the Admiralty. Launches and torpedo boats patrolled the harbor, while coast guardsmen cleared prominent shore points of all observers. After the firing, screens were hung over the armor plates, and, during certain examinations by higher officials, even commissioned officers not directly concerned with the experiments were not allowed to come near the hulk at the dock, while special policemen turned their backs during the process of photographing the injured plates. Later, owing to the difficulty of maintaining the secrecy desired, the *Belleisle* was towed away from the dock and anchored offshore.

Under these conditions little information has been available, and the following meager account is from the reports of various English papers:

Preparation of hulk.—The forward end of the *Belleisle* was fitted up to represent a 20-foot section of an armored cruiser, the starboard side representing the *Drake* (14,100 tons) class, while the port side represented the cruisers of the *Monmouth* (9,800 tons) or *county* class.

For this purpose a 4-inch armor plate was built into the hull on the port side forward, similar to those supplied for the side armor of the *county* class of cruisers, while on the starboard side were 6-inch plates identical with those ordered for the *Drake* class. These plates were made by Messrs. Campbell & Co., of Sheffield, the principal feature of the plates being that they had been only partially “Krupped” in order to ascertain the elasticity and resistance of a plate under these conditions. Each of these sections of targets on the hull was painted in black and white squares, there being an area of 20 square feet for each target. In the center of each plate was a “bull’s-eye,” and also a small cross to indicate the junction of the angle irons of the ship with the armor plates. The upper deck in the vicinity of the target was covered with 2-inch steel plates, the remainder of the deck being, as it always had been, wood. The interior of the vessel near the target was fitted as sections of the *Monmouth* and *Drake*, with coal bunkers just inside of the armor, transverse bulkheads, mess deck, and all internal arrangements of that part of a cruiser.

The attack.—The attack was made by the gunboats *Pincher* and *Comet*, the former mounting a 9.2-inch gun, the latter a 6-inch gun, both guns being of the latest models fitted with telescopic sights. The 6-inch plate was attacked by the 9.2-inch gun while the 4-inch plate was attacked by the 6-inch gun.

A new form of lyddite, as well as armor-piercing projectiles and common shells were used. Lyddite shells were fired from the 9.2-inch gun.

The *Belleisle* was moored about a mile out, broadside to shore, while the gunboats were some 700 or 800 yards distant, placed so as to fire out to sea.

Firing was opened by the *Pincher's* 9.2-inch gun at the 6-inch plate. Two rounds were discharged, and then two with the 6-inch gun of the *Comet*.

Afterwards, the *Belleisle* was swung around and the 4-inch plates attacked by two rounds from the 9.2-inch gun, and then by four rounds from the 6-inch gun, making in all ten shots. Between each two rounds, the Admiralty party visited the ship and made careful observations of the results, taking photographs of the effect of each shot on the plate.

Sixteen shots were to have been fired, but owing to injuries from the attack, due to one shot, penetrating between "wind and water," and causing the ship to leak seriously, the trials were discontinued and the *Belleisle* was towed back to Portsmouth. Use of collision mats and steam pumps enabled her to be kept afloat.

Results of the attack.—Two of the 4-inch plates, representing the *Monmouth* class, were completely perforated, and one of the 6-inch plates, representing the *Drake* class, was also pierced, the 9.2-inch armor-piercing projectile going through the 6-inch plate and the 6-inch projectile through the 4-inch plate.

In each case an armor-piercing projectile got through, the common shell having broken up harmlessly against the plates.

The lyddite shell likewise failed to crash through, but the formidable shower of splinters which each lyddite-filled projectile threw out as it burst, showed that this shell would have a terribly destructive effect when fired at unarmored ships.

Some remarkable results followed the explosion of the lyddite shell. The *Pincher* fired these shells at 300 yards while the *Comet* was 2,000 yards away, abeam of the *Belleisle*; yet on the shell exploding on the side of the hulk, fragments rebounded and fell on the deck of the *Pincher* to the rear, and were also scattered near the *Comet*. Some of the fragments falling on the deck of the *Pincher* were less than two ounces in weight, and few weighed more than eight ounces, but all were heavy enough to do injury had they struck the men on deck.

English accounts give the following as the results of the experiment:

1. Four-inch armor, especially prepared, was penetrated by 6-inch shot, the shot much disturbing the coal protection, but doing little real damage.

2. The 9.2-inch lyddite shells were not effective against thin armor.

3. A 6-inch plate resisted 6-inch shot.

4. The minimum safe range, of the firing vessel, for firing lyddite is 2,000 yards.

5. Until a ship has been riddled by armor-piercing projectiles, lyddite is useless, unless exploded inboard on deck.

Some comment was made upon the fact that the conditions of the test were in every way opposed to the conditions of warfare.



BEFORE THE TRIGGER IS PULLED.



AFTER FIRING AND BEFORE THE TRIGGER IS RELEASED.

THE MARS AUTOMATIC PISTOL

SECTION III.

SMALL ARMS.

THE "MARS" AUTOMATIC PISTOL.

A NEW AUTOMATIC PISTOL.

This pistol is of the magazine type, the magazine being contained in the handle. It is claimed that it can fire a heavier bullet and take a heavier charge than any other existing automatic pistol. Three sizes of pistol are made, namely, $8\frac{1}{2}$ millimeters, 0.36 inch, and 0.45 inch. The ability of this pistol to carry heavier projectiles lies in the fact that the breech remains closed until the bullet has left the barrel, so that there is no chance of the cartridge bursting by being withdrawn while there is still pressure on it.

GENERAL DESCRIPTION.

From the sectional drawing given, its general working can be gathered. The barrel *T* is free to slide backward and forward horizontally. The effect of discharging a shot is to send the barrel backward, and it carries with it the whole of the breech mechanism, the block remaining locked in the barrel. On the under side of the barrel there is a guide block *a*, which fits and slides in a circular-shaped slot in the front part of the stock of the pistol. In the slot is a spiral spring r_1 , which has at its rear end a buffing arrangement *g*, which is provided with a plunger and strong spring, so as to finally absorb the energy of the recoil. The buffer-stop and spring are kept from moving backward in consequence of the removable pin *h*, which goes from side to side of the stock. The spring r_1 is made as light as is practicable, so as to allow as quick a backward movement as possible, while at the same time insuring that when the recoil is over the barrel shall immediately be forced to its extreme forward position. The spring r_2 of the buffer *g* is, on the other hand, made strong, as it is there that most of the surplus energy expends itself.

The breech mechanism is provided with a breechblock B_1 , the forward end of which has upon it three taper lugs *l l l*, set at 120° apart. The breechblock has also on its forward end—placed close beside one of the lugs—a spring cartridge extractor of the usual form. The breechblock has about its rear end a coiled spring, which gives it a tendency to turn to the right. A stud on the outside of the block

works in a slot which limits its travel to about a quarter of a revolution. As the spring tends to turn the breechblock to the right, this stud is, unless prevented, always pressing against the upper end of the slot. This is the locking position when the breech is closed. The unlocking is brought about by means of a lever MN being made to press on the stud and to bear it downward, thus revolving the block and releasing the lugs from the breech. The breech mechanism is actuated by two springs r_2 (figs. 3 and 5), which are entirely separate from the barrel spring already described. The forward end of the breechblock carriage is provided with two parallel rods τ_1, τ_2 (figs. 3 and 5), which are contained in holes bored in the stock, parallel to and underneath the barrel. Around these rods are two coiled springs, secured by studs screwed into the ends of the rods. It is evident that when the breech mechanism is forced back with the barrel, these two springs are compressed and tend to pull the mechanism forward. Underneath the breechblock, and shown dotted in the engraving, is a loading tray apparatus DG, which embraces the top cartridge in the magazine. This is hinged to the carriage at s, and on the pistol being discharged is pulled backward, drawing with it the cartridge it has withdrawn from the magazine, and from under that portion c of the magazine which prevents the cartridges being forced directly out of the top.

The breechblock and its action.—The closure of the breech is similar to that of the modern heavy rifles of high power, being an interrupted screw of zero pitch. The lugs l (figs. 1, 3, and 4) enter the screw box at the spaces l_2 (fig. 2_a), and locking is effected by rotation of the block B_1 to the right.

The spiral spring r_5 (fig. 1) exerts a constant effort to keep the block rotated to the right, i. e., always locked in the screw box. For the action of the mechanism in its automatic functioning, the block must be unlocked against the action of this spring, and held unlocked during recoil, ejection of the empty case, and loading of the fresh cartridge. These operations are effected as follows:

Upon firing, the breech being closed and the block locked, the barrel and breech mechanism entire move to the rear for the full length of recoil and then start to return to battery. For a very short distance the entire breech mechanism, with the breechblock yet locked, moves forward together until the toe of the side bar Z (figs. 3 and 4) takes on the toe of the bell-crank lever d . The continuation of the return to battery requires Z to slide in its slot in the breechblock carrier, restraining the toe N of the bell-crank lever MN (figs. 3 and 5), causing it to revolve and by catching on the pin ζ to revolve the breechblock to the left and unlock the plug B_1 . As soon as the block is unlocked the barrel flies forward to its initial position, while the breechblock and its carrier Z_1 remain at the rear. These operations

having taken place, the shell has been ejected and the fresh cartridge presented for loading. This condition of affairs is illustrated in fig. 4. Upon the release of the pressure on the trigger the block and carrier fly forward, the fresh cartridge is inserted, the piece locked, and ready for firing. It is to be noted here that upon the release of the side bar Z from the toe of lever d , that the lever MN is free to revolve and the spiral spring r_5 of the breechblock would rotate the block to its closing position and prevent the entrance to the breech by presenting the lugs l_1 of the block in front of the lugs l_1 of the breech, instead of presenting the lugs l of the block to the blanks l_2 of the breech. It is necessary then to keep the block B_1 held rotated against the spring until after the block has entered the breech. This is accomplished as follows:

On the rear of the underside of the breechblock are cut a series of ratchet teeth, which engage in the ratchet stop $\epsilon\eta$, fig. 3_a. When the block has been rotated by MN (figs. 3 and 4), the ratchet lever $\epsilon\eta$ takes in the ratchet teeth e_1 , fig. 3_a, and holds it firmly. It remains held until the instant it has fully entered the breech. At this moment the toe ϵ (figs. 3 and 3_a) catches on the breech mechanism casing and is tripped, thus releasing the catch $\epsilon\eta$. As soon as released, the spiral spring r_5 inside of the breechblock reverses the plug to the right and locks the breech.

As indicated by the drawings, the hammer is cocked by the recoil of the barrel and breech mechanism.

Loading operations.—In the upper portion of the stock is a loading tray DG, fig. 5, hinged at s . This tray first presents itself in rear of the top cartridge of the magazine. Upon recoil after firing, the rods τ_1 , τ_2 , which end in the jaws F (fig. 3, bottom plan, and fig. 4), move to the rear past the upper lip cc_1 of the magazine and, catching the cartridge as indicated in the bottom plan of fig. 4, carries it to the rear and places it in the loading tray. As the loading tray moves to the rear it passes over the hammer A, as shown in the lower view of fig. 7, and is compelled to rise, swinging in a vertical plane around the pivot s . The cartridge is thus carried up and placed in front of the breechblock, as shown in fig. 4, ready to be entered by the block as it returns to battery. Having performed its function, the tray returns to its initial position.

The magazine is held in place by the stop p in the stock, figs. 1 and 4. This stop may take in either notch on the magazine. When in K_1 the pistol is ready for magazine fire; when in K_2 one shot at a time may be fired.

The magazine holds a different number of cartridges, from 8 to 11, according to the caliber of the bullets, and with a 10-cartridge magazine, with refills ready to hand, an expert has, we are informed, been known to fire 24 shots in ten seconds. The pistol itself is neat, and balances well in the hand, while its weight is 2 pound and 10 ounces.

TESTS.

These consisted almost entirely of penetration tests at point-blank range. In order to compare the relative effect of the discharge of a .45 revolver cartridge with a .45 cartridge in a Mars pistol, a shot was fired from a Colt revolver at a series of inch boards placed vertically with an inch air space between them. The result was that the Colt bullet pierced six boards and the Mars bullet perforated ten boards and dented the eleventh. The weight of the Colt bullet, which is entirely of lead, was 265 grains; of the Mars, which is nickel-cased, 220 grains. The Colt charge is 7 grains of cordite; that of the Mars 14 grains. The muzzle velocities are 670 and 1,250 foot-seconds, while the energies are 270 and 760 foot-pounds respectively. Trials with the $8\frac{1}{2}$ mm. and .360 Mars pistols, with bullets weighing 140 grains, with 10 grains of cordite, and 160, with 12 grains of cordite, respectively, showed the penetration to be sixteen boards in the first case and twelve boards in the second. As a comparison with these, shots were fired from the Mauser .360 pistol with a projectile weighing 86 grains, and a Colt .360 pistol with a bullet weighing 130 grains. The Mauser, the charge of which is $5\frac{1}{2}$ grains, penetrated ten boards, while the Colt, whose charge is 6 grains, buried itself in the ninth board, as against a penetration of sixteen boards by a .360 Mars bullet.

As to accuracy of fire, there were no tests to show this, but it is stated that a Mars pistol 18 inches long, with correct sight, fired from a rest, will keep all its shots on a 4-foot square target at 1,000 yards. With a detachable stock it is claimed that it will form an excellent weapon for cavalry or mounted infantry, having the advantage, due to its handle, that it can be manipulated with one hand, leaving the other free to manage the horse.

THE HYLARD RIFLE.

The actuating or main spring F is, as will be seen from figs. 2 and 3, of the flat form. It is held in position by means of a circular projection on its rear end, which slides into a similarly shaped hole in a bracket forming part of the mechanism frame—this hole not going quite from side to side of the bracket—and is held there by a screw—not shown—which keeps both it and the spring below it in position. It will be seen that the free end of the spring enters a slot in the hammer G, which is pivoted at H. There is a notch K in the hammer G, into which the end of the trigger J is pressed in the ordinary manner by a spring. In fig. 3 the mechanism is shown cocked and nearly ready for firing, but not quite, as will be explained. The action of cocking is brought about by the turning of the bolt from its position when closed—i. e., with the lever turned down to the right—to a position

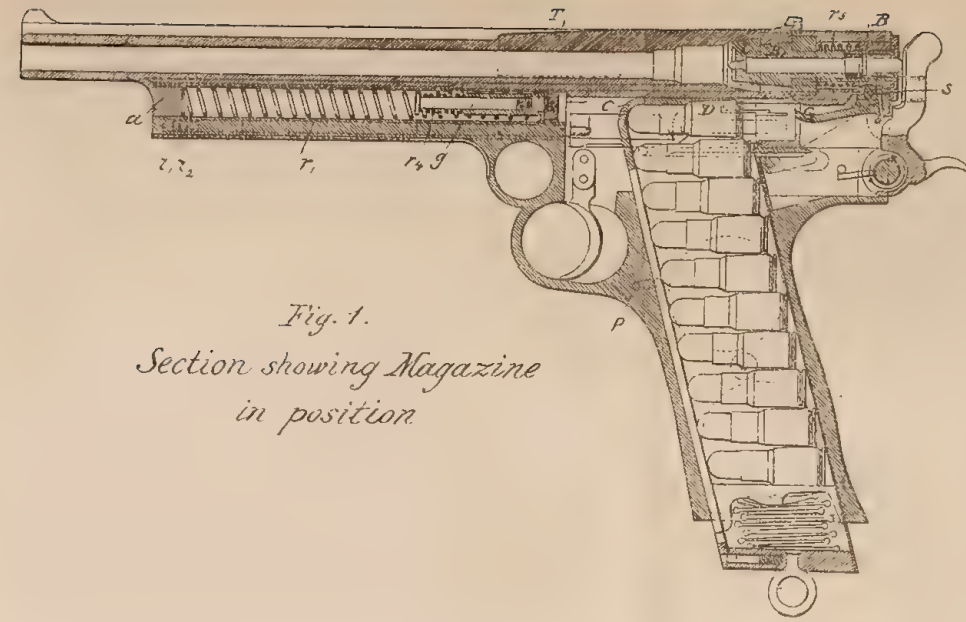


Fig. 1.
Section showing Magazine
in position.

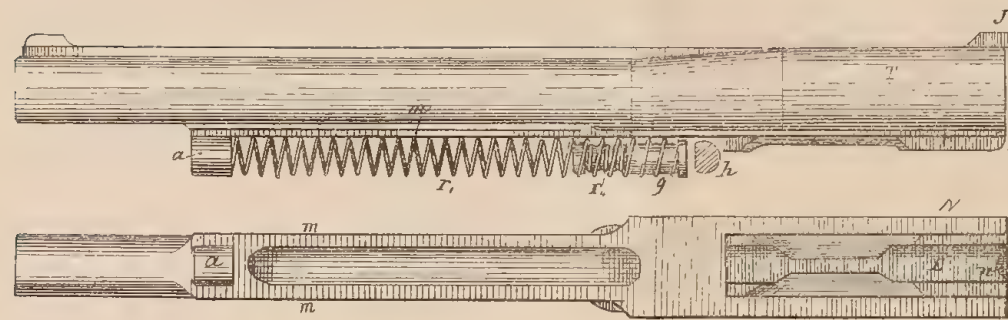


Fig. 2.
Bottom plan and elevation of barrel showing buffer.

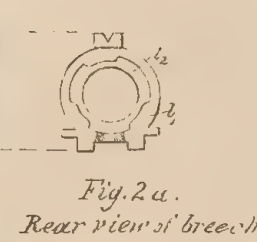
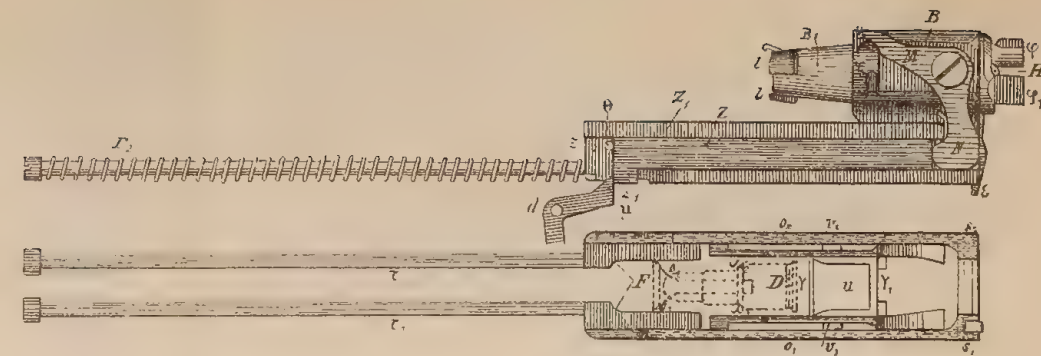


Fig. 2 a.
Rear view of breech.



Figs. 3.
Bottom plan and elevation of breech block carrier with block in position.

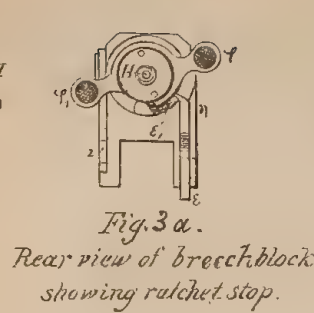


Fig. 3 a.
Rear view of breech block,
showing ratchet stop.

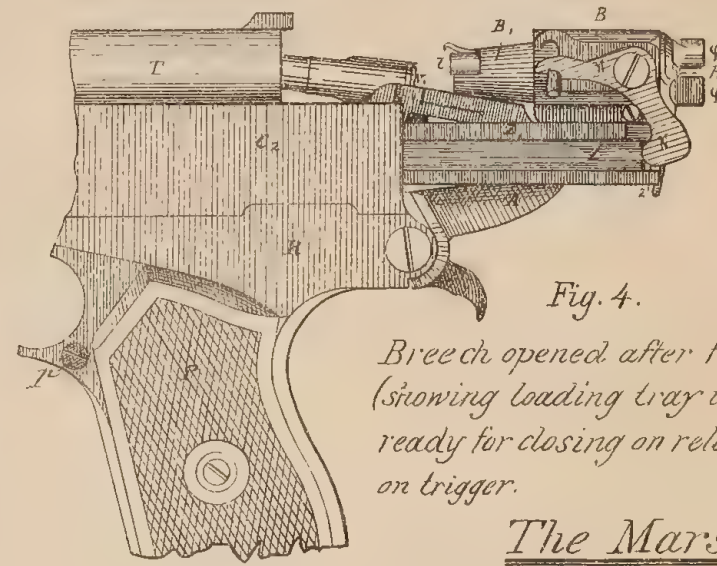
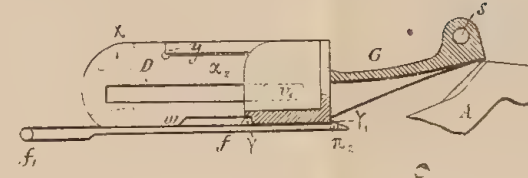
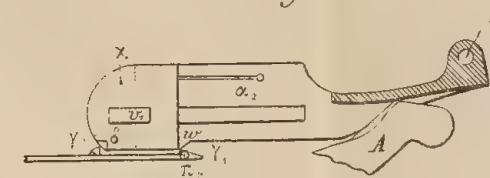


Fig. 4.
Breech opened after firing,
(showing loading tray in position)
ready for closing on release of pressure
on trigger.



Figs. 6.



Loading Tray.

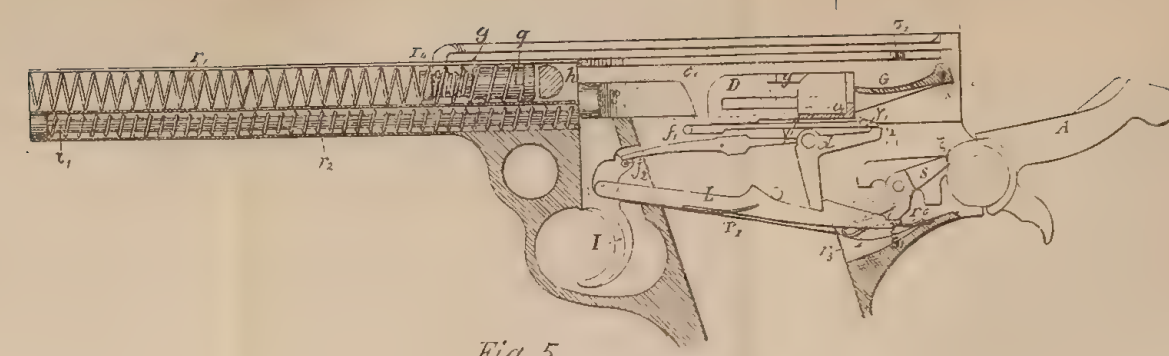


Fig. 5.
Loading and Firing Mechanism.

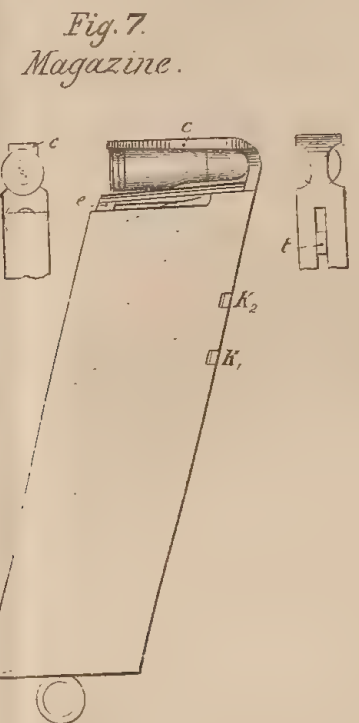


Fig. 7.
Magazine.

The Mars Automatic Pistol.
(Gobbett - Fairfax)

with the lever pointing vertically. This turning movement caused a cam, forming part of the bolt, to depress the small cocking piece L, and hence the spring F to which it is hinged in the manner shown. This depression is carried to a point when the notch on the top of the cocking piece is brought against the portion M of the frame and remains there. This movement is sufficient to allow the end of the trigger J to be forced into the notch K. As we have said, the mechanism is now cocked, but it is impossible to release the main-spring F by pulling the trigger, since it is prevented from rising on account of the cocking piece L being caught and prevented from moving. When the bolt is pressed home and the lever turned, the rim N on the back of the bolt just touches the cocking piece L and disengages it, so that it is free to move when the trigger is pulled. Some such device as this is absolutely necessary. The next portion of the mechanism is the striker, and it possesses several interesting features. Its travel is very small indeed, only just enough to explode the cap of the cartridge. It is controlled by no spring, but is free to move in a cylindrical hole drilled in the bolt. In fig. 2 it will be seen that the hammer G has sent the striker forward and that it projects beyond the bolt head.

In fig. 3 the bolt is shown drawn back and the striker also withdrawn. The method of withdrawing the striker is simple and clever. The portion of the bolt marked P is loosely screwed into the main body of the bolt. It is kept from revolving when the bolt is turned by reason of its being caught by the sliding groove. The result, therefore, is that when the bolt is turned the screw is undone a quarter turn or so, and the effect of this is seen in fig. 3. Here it will be observed that P is no longer hard up against the bolt as in fig. 2, but is slightly separated from it. The striker O has a shoulder at Q, which is in cam form. The rear of the piece P is cammed in the same way, and the effect of the relative motion between the main portion of the bolt and the part P is that these two cammed surfaces are made to revolve against one another when the striker is drawn back. The makers and the inventor both claim that this arrangement of flat spring and detached hammer and striker is much more simple, stronger, and less likely to get out of order than that in which there is a coiled spring embracing and actuating a striker.

The magazine itself does not differ greatly from others. Some of its arrangements, however, are widely different from any that have come to notice. The cartridge platform is not pressed upward by a spring direct, but by means of the flat spring R acting on the end of the lever S, which is pivoted at T. The trigger guard is pivoted at U, and it has an extension V. When the trigger guard is pressed down, this projection V comes against the spring R, and lifts it, with the result that the lever S is depressed to the bottom of the magazine.

This has two advantages. When the platform, which is hinged to the end of the lever *S*, is depressed to the bottom, nothing holds the cartridges, which can then be easily shaken out of the magazine by turning the rifle upside down. This is extremely useful in case of a jamb. Then, again, when the platform is at the bottom, there is no resistance to placing the cartridges in the magazine, into which they can be dropped by hand quite quickly and with no pressing. Then the closing of the trigger guard over the trigger allows the spring to again act on the lever *S* and to put pressure on the cartridges.

MAUSER MAGAZINE FOR RIFLES.

The magazine for rifles which is described is designed to contain ten flanged cartridges in as small a space as possible. The portion of the magazine projecting beyond the stock takes the form of a curve, running from the trigger guard gradually up to the body of the stock. In order to allow of this construction the cartridges are arranged within the magazine in a fan-shaped manner, the depth of the double row of cartridges gradually decreasing from the wide rims to the narrower noses.

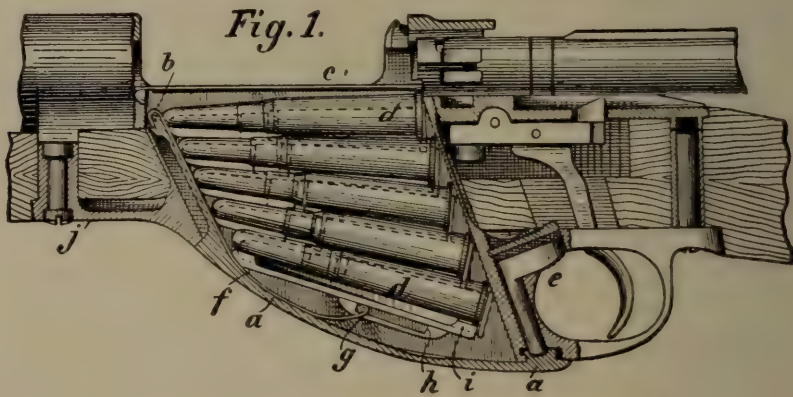


Fig. 2.



Referring to the accompanying illustrations, fig. 1 is a longitudinal section of the magazine, and fig. 2 is an underside view of the casing and stock.

The curved bottom plate *a* carries the cartridge-lifting platform and its spring, and is adapted to be detached from the stock. The plate *a* is continued right up to the point *b*. It extends into the magazine *c*, so forming the front wall of the magazine, against which rest the noses of the cartridges *d*. The plate is secured in the closed position, as illustrated, by means of the spring catch *e*, the action of which will be understood on referring to the drawings. The spring *f* is suspended

Fig 1

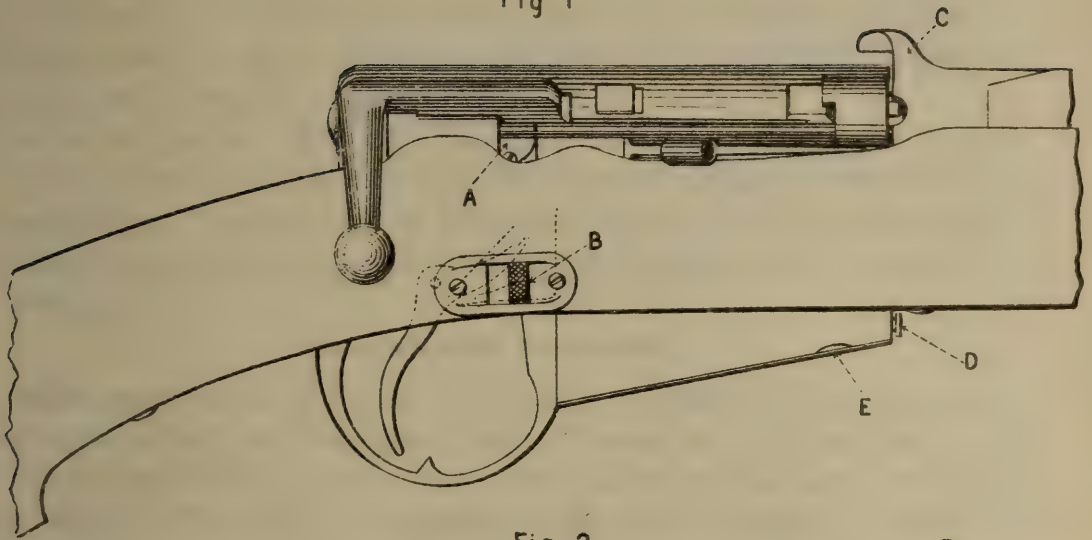


Fig 2.

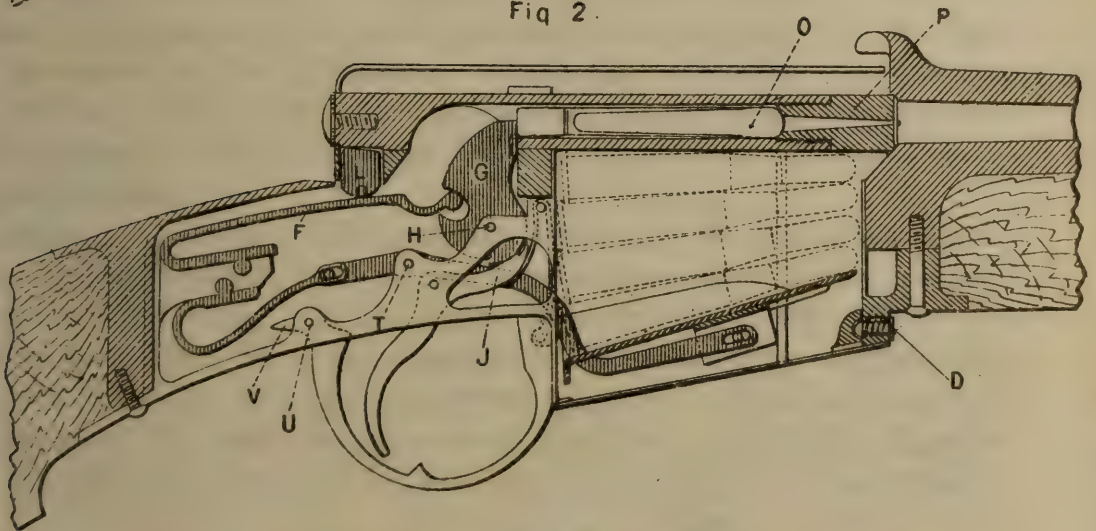
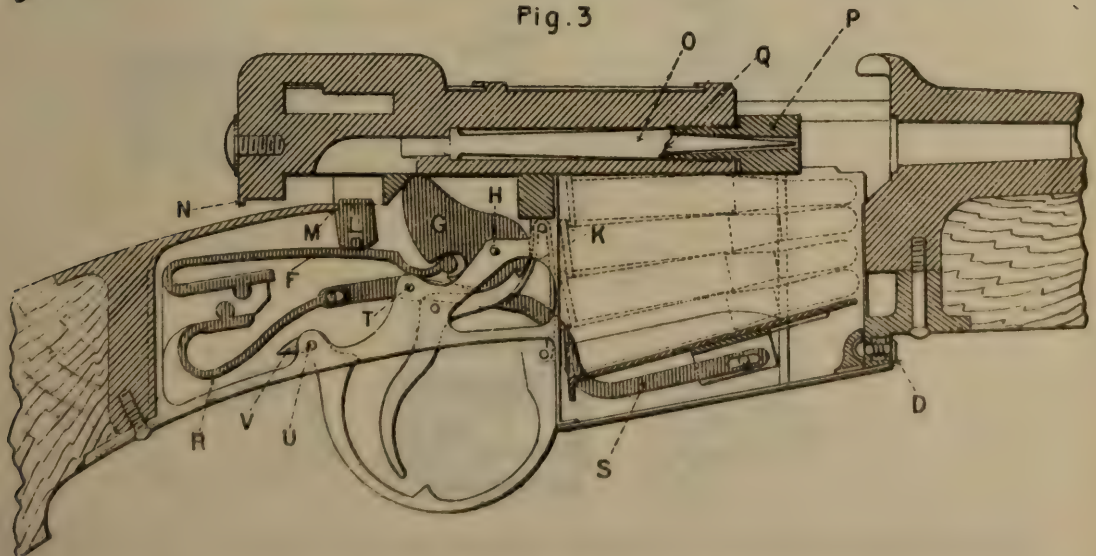


Fig. 3



HYLARD RIFLE—BREECH MECHANISM

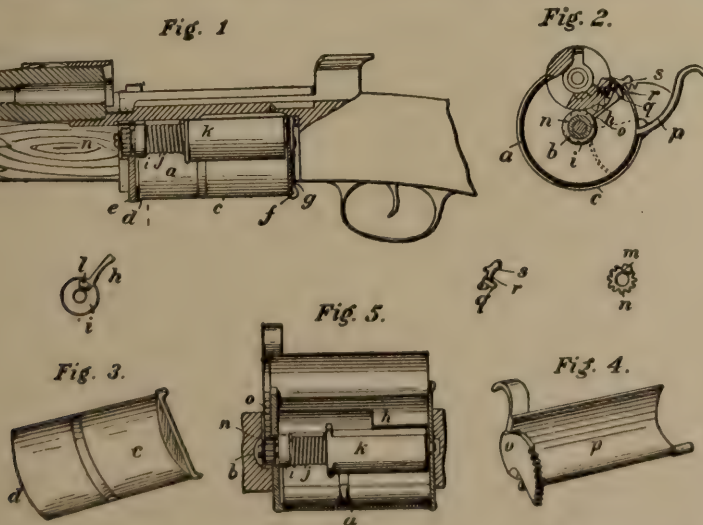
from the top *b* of the plate *a*. Its end *g* is adapted to slide in a guiding slot *h* cut in the cartridge-lifting platform *i*, so that it may move and adjust itself to the motion and position of the platform during its travel up and down the magazine box.

The cartridges are fed into the magazine from a clip, the flanges occupying the deep back part and the noses the shallow front part of the magazine. This method of arranging allows of the bottom plate *a* gradually curving up from the guard until it merges into the curve of the stock *j*.

KRAG MAGAZINE MECHANISM.

A rifle magazine of the cylindrical type is described in this article. The center of the circular casing which forms the cover of the magazine is occupied by a core, about which a spring-actuated cartridge lifter works. This lifter is automatically pulled round, or cocked, in readiness for pushing the cartridges out of the magazine, by the opening movement of the lid through which the cartridges are inserted. The closing of the lid releases the carrier, which, under the influence of its spring, is caused to force the cartridge around and out of the circular chamber.

In figs. 1, 2, and 5 of the annexed drawings the magazine is illustrated in longitudinal, vertical, and horizontal sections. The magazine consists of the casing *a* in the center of which is fixed the core *b*. The bottom part *c* (fig. 3) of the casing is so constructed as to allow of its removal from the main portion of the magazine. The forward end *d* of this part fits into the groove *e* in the front wall of the magazine, and its rear end is secured by the hook *f* on the end of the spring *g*.



The cartridge carrier *h* forms part of the ring *i*, which works about the core *b*. Attached to the inside of the ring *i* is the end of the spring *j*, the other end of which is secured to the larger portion *k* of the core. Upon the outside of the ring *i* the projection *l* is formed. This projection is adapted to be engaged by the projection *m* standing up from the face of the toothed pinion *n*. The toothed pinion is mounted so

that it is free to rotate upon the extreme end of the core *b*. The teeth of the pinion are engaged by the teeth cut upon the inwardly extending projection *o* of the lid *p* (fig. 4). It will be understood that when the lid *p* is turned down to open the magazine the pinion *n* is caused to rotate. This motion brings about the engagement of the projections *m*, *l*, and the ring *i*, to which the cartridge lifter is fixed, is consequently turned. In this way the cartridge lifter is drawn round with the opening of the lid *p* to the position shown in fig. 2. In this position the lifter is held by the little spring-actuated hook *q*, which works on the lever *r*.

The cartridges can, with the parts in this position, be dropped into circular casing. After they have been inserted the lid *p* is pushed up in order to close the magazine. The closing movement causes the lid *p* to strike against the nose *s* of the lever *r*, and in this way the hook *q* is lifted from engagement with, and so releases the lifter *h*. When the lid *p* is fully closed down the hook *q* again operates to lock it in the closed position. When the lid has again to be opened, pressure upon the nose *s* releases the hook from engagement with the lid.

SECTION IV.

TARGET PRACTICE AND GUN TRIALS.

NOTES ON BRITISH NAVAL TARGET PRACTICE.

Much greater interest in good shooting is shown in the British navy. Admirable records have been made by the *Terrible* and the *Bargleux* in China, while in the Mediterranean other ships have accomplished excellent results.

Good practice is now being made at ranges never before considered, at any rate for real fighting, and evidently, if even 10 per cent of hits can be made at 5,000 yards and 5 per cent at 7,000 yards, it would be worth while, in a chase, to open fire at the latter range, and possibly at the opening of an engagement.

The conditions of prize firing vary according to the nature of the guns. The 12-inch and 9.2-inch guns fire for six minutes only (the vessel steaming at 8 knots), at a range varying from 1,400 yards to 2,000 yards, and at a target of 15 feet height, 20 feet top, and 50 feet bottom, the whole giving an area of 525 square feet. The 6-inch quick-firing guns fire for two minutes (the vessel steaming at 12 knots), and at a range varying from 1,400 yards to 1,600 yards, at a target giving an area of 300 square feet. It will thus be seen that the heavy guns fire at longer range than the quick-firing, but their target is larger and the speed slower. On the other hand, as their rate of fire is slower, the distance varies more with the big guns than with the quick-firers. The function of the heavy guns is essentially to pierce the armor which stops the quick-firer's projectile, hence practice with the former is mainly judged by the number of hits, whereas the capabilities of the quick-firer are estimated by the weight of metal hitting.

Again, the efficiency of either type of gun depends upon the rapidity with which it can hit. Consequently, rapidity of fire must, or should, conduce to more hits, as there is less time for the distance to change between the rounds. Indifferent gunnery has invariably been ascribed to lack of practice by the gunners, and to improve this state of affairs one well-known naval officer has long devoted himself to perfecting a system of his own for training men to aim accurately. The system includes a "dotting machine" for training the pointer to keep the sights always on the object, independently of the rolling of

the ship, and an extemporized loading apparatus, with which daily exercise is to be carried out.

The fact that Captain Scott's methods of training are being followed in other ships indicates that greater interest is now taken in aiming practice with heavy guns.

Notwithstanding the fact that the year 1901 gave some remarkable records of target practice in the British navy, the average record of this service for 1901 is little better than that for 1899 and 1900, the improvement being confined to exceptional shooting on the part of a few crack ships.

THE "TERRIBLE'S" LATEST PRACTICE.

The *Terrible* established the record last year at the annual prize firing with heavy guns (6-inch) by making a percentage of 77. This score was 20 per cent higher than the next best ship's performance in the British navy, and has now been beaten with a percentage of 80 for 6-inch guns, this being equivalent to the *Scylla's* record with 4.7 guns.

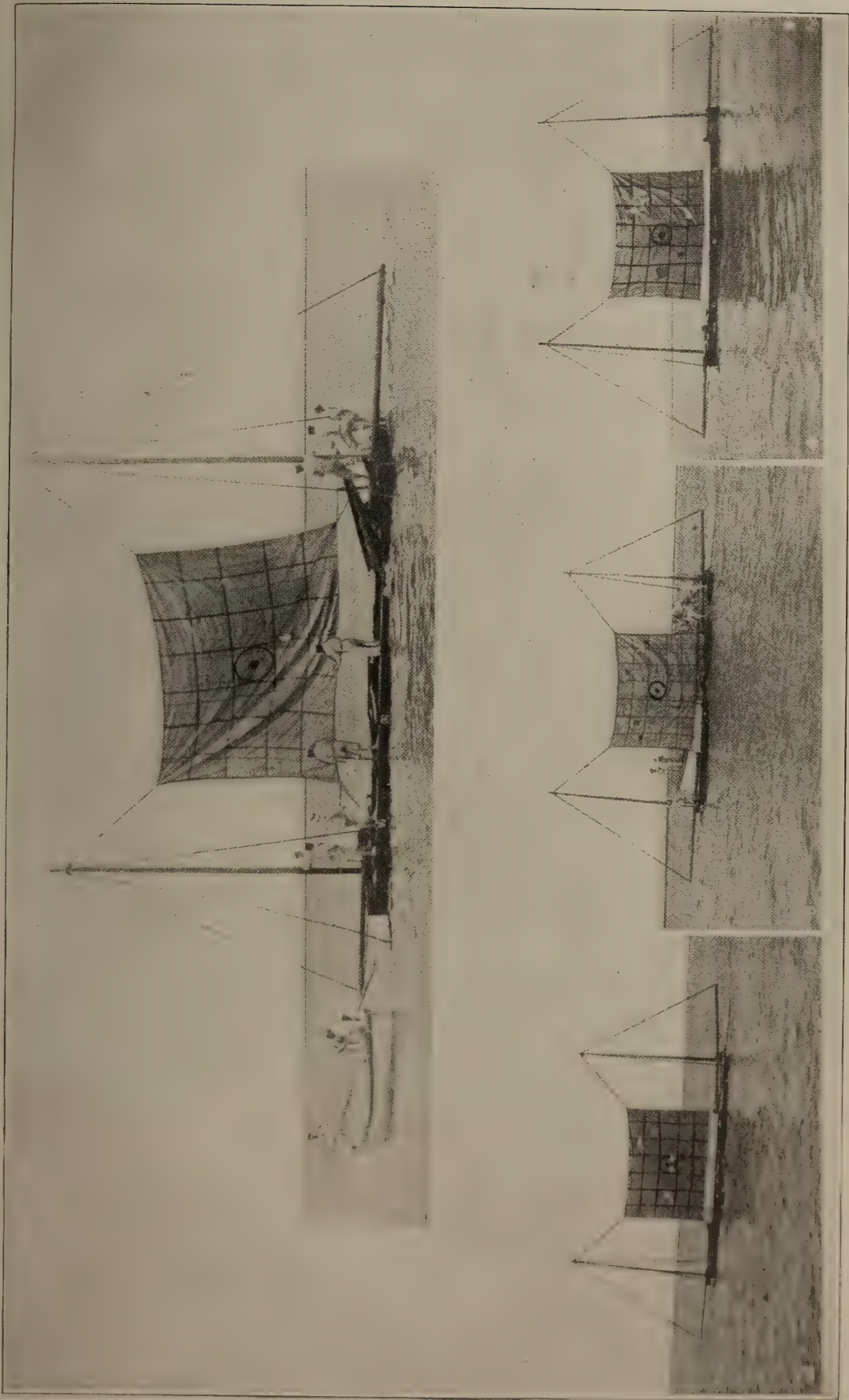
In 1900 the score was so large that many pardonably doubted the accuracy of the figures, owing to the great difference between them and those next in point of merit. But in order to obviate all suspicion regarding the results obtained on this occasion the time and marking of each gun was taken by several independent observers, in addition to the umpires. The regulations state that two umpires from another ship are to witness prize firing; the *Terrible* had five.

Analysis of firing.

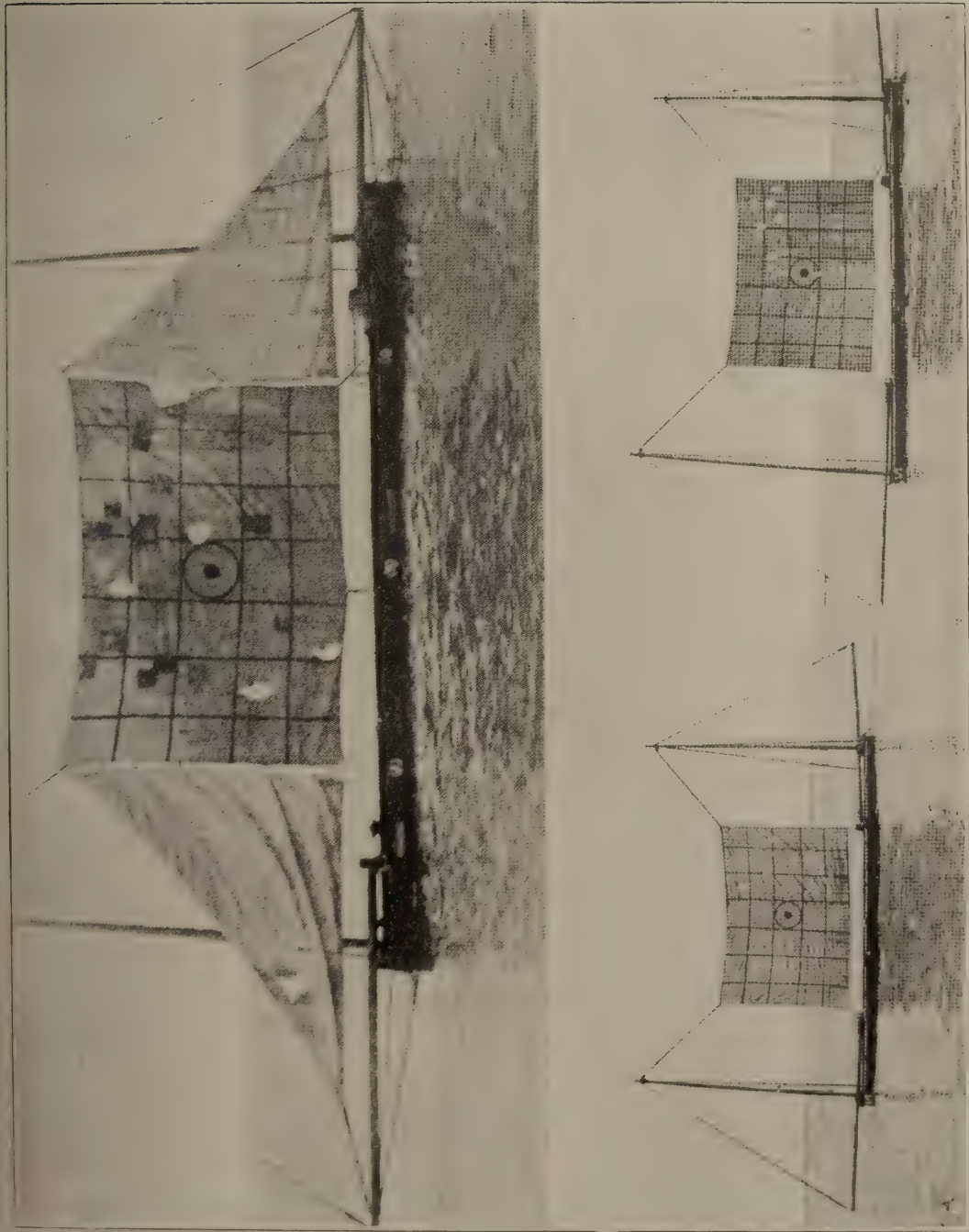
6-INCH GUNS (12).

Guns as fired.	Rounds.	Hits.	Percent- age.
No. 1.....	10	10	100
2.....	11	8	85.7
3.....	11	11	100.6
4.....	11	9	88.3
5.....	11	9	87
6.....	9	7	85.7
7.....	10	10	87.6
8.....	13	8	85.7
9.....	12	9	82.6
10.....	9	6	79.5
11.....	11	6	78.8
12.....	10	9	79.6
Totals	128	102	79.6
Last year, 1900.....	104	80	76.8

REMARKS.—Duration of each run 2 minutes; speed of ship 12 knots; number of rounds per minute average 5.3; number of hits per minute average 4.2; ten men made possibles (each gun being fired by the Nos. 1 and 2, i. e., one minute each man), one man making 8 rounds 8 hits in his minute; weight of gun 7 tons; weight of projectile 100 pounds.



THE TERRIBLE'S LATEST PRACTICE.



THE TERRIBLE'S PRACTICE (CONTINUED).

- 5, After 9.2-inch gun, 12 rounds, 9 hits in 6 minutes;
- 6, No. 6, 6-inch port gun, 13 rounds, 8 hits in 2 minutes;
- 7, No. 1, 6-inch starboard gun, 10 rounds, 10 hits in 2 minutes.

Analysis of firing—Continued.

9.2-INCH GUNS (2).

	Rounds.	Hits.	Percent- age.
F barbette.....	10	5	50
A barbette.....	12	9	63.6
Totals.....	22	14	64
Last year, 1900	15	9	60

REMARKS.—Duration of run 6 minutes; number of rounds per minute 1.10; number of hits per minute 1.1; weight of gun 25 tons; weight of projectile 380 pounds,

In the fleet the average hits per gun per minute with 6-inch quick-firing guns is 1.1. The *Terrible* made as much as this with 9.2-inch guns, and four times the number with her 6-inch guns.

The targets depicted in the accompanying illustrations of the *Terrible's* latest practice were of strict service dimensions, but two masts were fitted instead of three. The canvas was triced out from each corner, and no spreaders were used. The weather was fine throughout.

Petty Officer Grounds, who had always made a high score with the “dotter,” and whose gun’s crew was among *the best at loading drill*, made the maximum score with 8 rounds, 8 hits inside the minute. Petty Officers Taylor and Kewell scored 9 hits out of 12 from the after 9.2-inch gun.

The shooting and loading of the after 9.2-inch gun is worthy of notice. In six minutes this gun fired 12 rounds and hit the target 9 times, which is 1.5 hits per minute. This is more than the fleet average for 6-inch quick-firing guns. As it was anticipated that the firing would be more rapid than that generally accepted for 6-inch guns, and in order to avoid question regarding the results obtained on this occasion (for the shooting of the *Scylla* in 1899 and that of the *Terrible* in 1900 was barely credited in the British service), the time and marking of each gun were taken, as stated, by several independent observers in addition to the five umpires, though the regulations state that two umpires from another ship are all that are necessary to witness prize firing.

METHOD OF DISTRIBUTING PRIZE FIRING MONEY ON THE “TERRIBLE.”

On board the *Terrible*, it is the custom to divide the admiralty prize money by the total number of hits made, and then to pay each gun’s crew according to the number of hits they make. In 1901 the total prize money for the 6-inch guns was £19 2s. 6d. The gunners of the 6-inch guns made 102 hits. This gave 3s. 9d. per hit. The gun’s crew to which Petty Officer Grounds belonged made 10 hits, and he received, as captain of the gun, ten times 3s. 9d.; in all, £1 13s. 9d. This he divided with the eight other men forming the gun’s crew.

PRIZE FIRING IN THE CHANNEL SQUADRON.

The return of the annual prize firing with heavy guns of the Channel fleet ships has been published. In the case of the 13.5-inch gun two runs of six minutes for each gun were made, but for the 12-inch guns one run of six minutes was made for each gun. The results were as follows:

Vessel.	Number guns.	Caliber.	Time firing.	Shots.	Hits.	Per cent.	Per gun per minute.	
							Shots.	Hits.
		Inches.	Minutes.					
Repulse	4	13.5	12	25	10	40	0.52	0.21
Resolution	4	13.5	12	28	9	32	.58	.19
Mars	4	12	6	26	11	42	1.08	.46
Magnificent	4	12	6	23	7	30	.96	.29
Majestic	4	12	6	22	7	32	.92	.29
Prince George	4	12	6	26	7	27	1.08	.29
Hannibal	4	12	6	22	8	27	.92	.25
Jupiter	4	12	6	20	6	30	.82	.25
Mars	12	6	2	112	62	55	4.67	2.58
Majestic	12	6	2	123	52	44	5.13	2.17
Repulse	10	6	2	77	39	51	3.85	1.95
Jupiter	12	6	2	97	42	43	4.04	1.75
Resolution	10	6	2	61	31	51	3.05	1.55
Hannibal	12	6	2	84	35	42	3.50	1.46
Prince George	12	6	2	96	34	35	4.00	1.42
Furious	6	4.7	2	73	26	36	6.08	2.17
Arrogant	6	4.7	2	63	19	30	5.25	1.60
Minerva	6	4.7	2	68	28	26	5.67	1.50
Pactolus	8	4	2	95	20	21	5.94	1.25

The shooting by the 13.5-inch guns of the *Repulse* and the *Resolution* is remarkable, as these weapons have never enjoyed a high reputation; yet the *Repulse* secured 40 per cent of hits and the *Resolution* 32 per cent. The best firing with the 12-inch gun was made by the *Mars*, which secured 42 per cent of hits, whereas the five other ships of the squadron armed with the same gun averaged only about 30 per cent. The *Mars* is evidently the crack ship of the squadron in gunnery, for with the 6-inch gun she averaged 55 per cent, making 62 hits with 112 rounds. The *Repulse*, though firing only 77 rounds, made 50 per cent, while the *Majestic*, firing 123 rounds in the same time, made 52 hits, or 42 per cent. The other ships armed with the 6-inch gun were content with a mean of from 30 to 35 per cent, though in each case the firing was much slower than in the case of the *Mars* and the *Majestic*. With the 4.7-inch gun the *Furious* was the only ship that came anywhere near 30 per cent, which is disappointing, having regard to the fact that the 4.7-inch has the reputation of being the most accurate gun in the British service.

GUN PRACTICE OF H. M. S. "CRESCENT."

A Bermuda correspondent reports the following record of practice by the *Crescent*, flagship on the North American Station:

So far as is known this is a record for 6-inch quick-fire gun firing as regards rounds and hits per minute, and was accomplished from guns with the old pattern three-motion breech mechanism, whereas most figures published lately represent firing from those guns which are fitted with the more modern one-motion breech action. With regard to the 9.2, this would appear to be a record as far as percentage of hits to rounds is concerned, and was also accomplished from an old mounting, carrying a gun with a slow breech motion. All the guns, including the 9.2, were hoisted out and landed for nearly three months for docking, the last gun being replaced by April 25, just fourteen days before the prize firing took place. The firing took place on the 9th of May, 1902.

6'' Q. F. 3-motion mechanism. C. P. I. mountings.

Gun.	Rounds.	Hits.	Rate of hits per minute.
1.....	14	12	6
2.....	13	12	6
3.....	12	11	5.5
4.....	12	11	5.5
5.....	13	10	5
6.....	12	10	5
7.....	11	9	4.5
8.....	12	8	4
9.....	10	7	3.5
10.....	12	5	2.5
11.....	9	5	2.5
12.....	9	5	2.5
	139	105	

Average of rounds per gun per minute..... 5.79
 Average of hits per gun per minute..... 4.37

9.2'' B. L. Mark VI, Mark III mounting: Rounds, 10; hits, 9.

Average of rounds per gun per minute..... .83
 Average of hits per gun per minute..... .74

THE DOTTER.

The following description of the dotter is taken principally from patent specifications:

The apparatus comprises a shifting target T, and a moving marking mechanism M. The former is operated by hand, while the latter is connected to the muzzle of the gun and moves with the gun as the gun is trained or elevated. Both T and M are fitted in a fixed frame F, and each can slide vertically or horizontally independently of the other. The recording mechanism comprises an electromagnet in circuit with the firing pistol of the gun, and when the gun pointer is satisfied with the alignment and pulls the trigger, electric connection is made, and the magnet *m* attracts the armature *a*, forcing the pencil or marker *p* forward against a sheet of paper moving with the target T, thus recording accurately the direction in which the gun was pointing when the trigger was pulled. Immediately on the release of the pistol trigger, the armature is released and a spring brings the pointer *p* back to its normal position. The target consists of a plate T, mounted on a bar B, along which it can slide for horizontal movement, whilst the bar B can slide up and down in the frame F.

A horizontal movement may be given by a cord *c*, which moves the target against

a spring *s*, so that when the cord is let go the target is pulled back by this spring. Pulleys *xx* may be employed for the purpose of reducing the extension on the spring.

The target is moved vertically by means of an endless chain *d*, connected to the bar at *E*, and driven by a handle *f*. The speed in this case may also be reduced by gearing.

The dotter, or marking mechanism, *M* is connected to the gun barrel by a rod *K*, bolted to a wooden tompion *L*, secured in the muzzle of the gun.

In order to obtain practical results from training gun pointers with this machine there are two things which must not be done under the impression that the machine is being properly used. They are: (1) The target must not be held stationary and the gun elevated or trained in order to make a bull's-eye as the gun sweeps past the mark, and (2) the gun must not be held stationary with object of making bull's-eyes as the target sweeps past.

The target may receive the combined vertical and horizontal movement of which it is capable, in varying proportions, and the gun must be moved to *follow* the target, at the same time keeping the sights on the bull's-eye as accurately as possible. The vertical movement is the most important, involving as it does the proper elevation of the gun, and may be used to the exclusion of the other movements with good results.

A combination of the vertical and horizontal movements may be automatically secured by drawing the target frame *T* to the middle point of *B*, and the securing of the ring of the cord *c*, so that the end is fast and can not move. In this position a vertical movement of the bar *B*, by the handle *f*, will extend or relax the spring *s*, and thus produce a corresponding horizontal movement of *T* on *B* as *B* rises or falls.

The speed of the target should not be so great as to discourage the beginner in his effort to pick it up and follow it with the gun.

As a test of the efficiency of training or elevating mechanism, this machine is an excellent shop tool. The attempt to follow the target instantly develops the strong or weak points, in a most convincing manner, of the elevating and training mechanism of the gun in hand.

THE LOADING MACHINE.

This is a breechblock fitted to a false loading chamber, so that the shell may be removed from the machine. The shellmen of the gun are trained to load the machine with projectiles by hand, without the use of a rammer. It is stated that after some practice 6-inch shell, weighing 100 pounds, can be accurately and rapidly thrown by hand into the gun, and landed home without the use of the rammer. The first efforts at this drill resulted in considerable exhaustion to the men engaged, but continuous drill, with proper rest, enabled the feat to be easily accomplished.

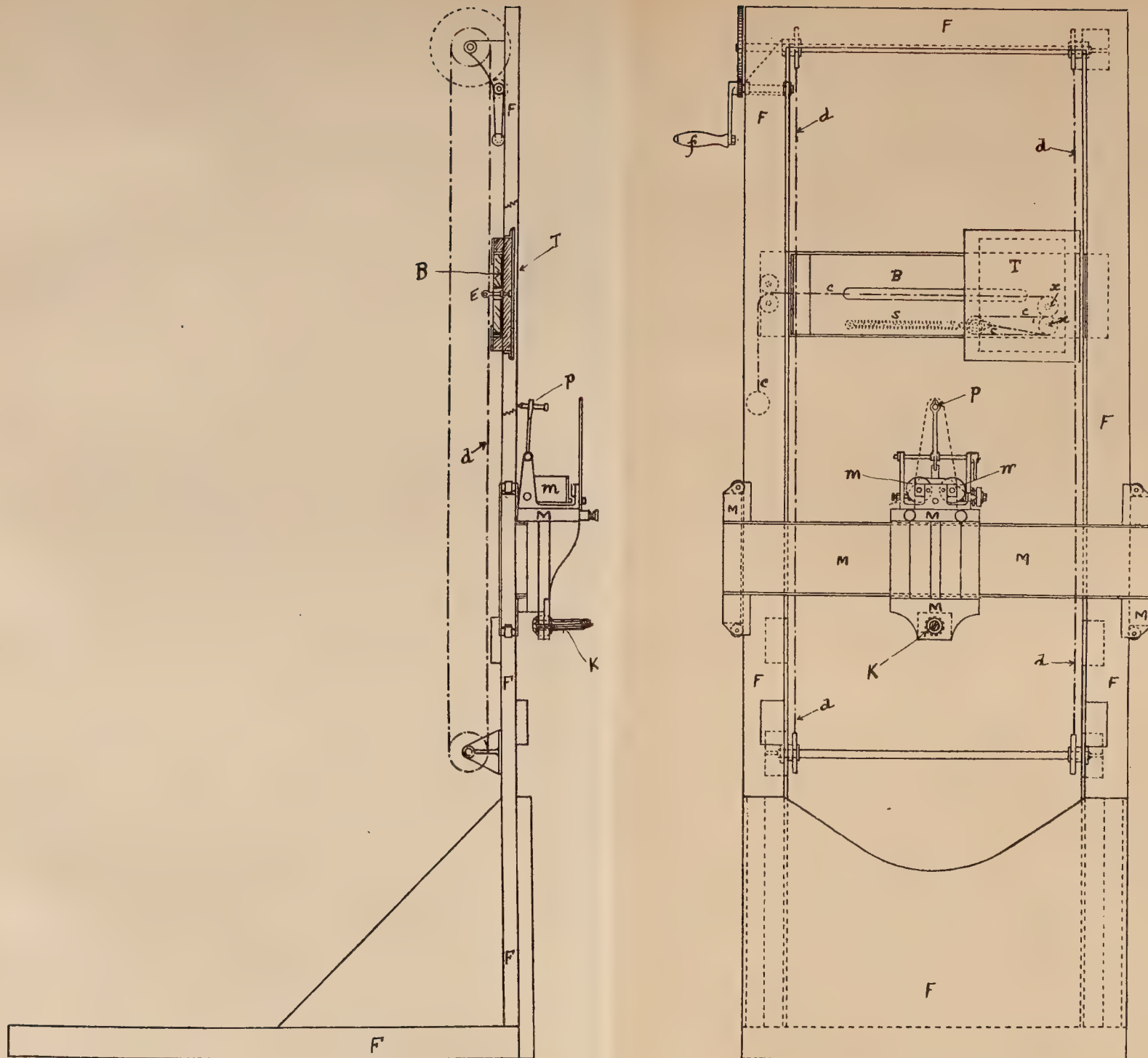
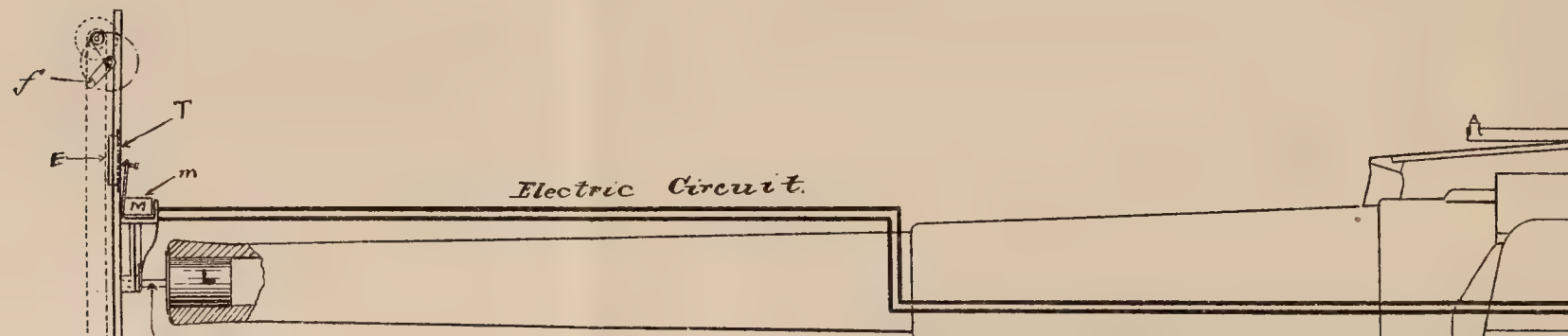
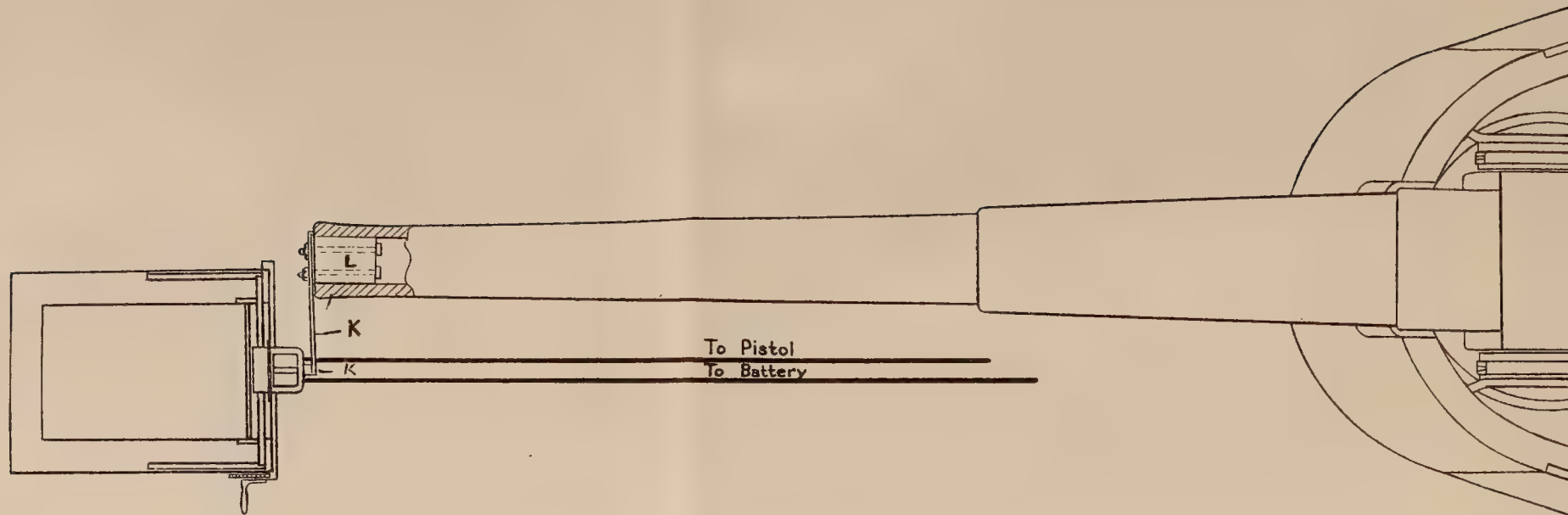


FIG. 1. THE "DOTTER" (CAPT. SCOTT'S AIMING MACHINE).



The necessity for a spare breech apparatus arises from the fact that in this practice the nose of the shell in new hands will batter the threads and projections of the screw box, and also from the necessity of having some means of removing the shell from the gun in a manner similar to that obtained in firing—that is, when once loaded the shell is not to be removed from the rear of the gun.

The *Barfleur's* gun crews were engaged in the exercise of loading 20 rounds of common shell and cartridge, going through the motions required in actual loading and firing. A prize of \$20 was offered to the gun's crew which loaded the gun with 20 rounds in the quickest time. The crew winning the prize accomplished this in 1 minute and 24 seconds.

Since the above notes were written contests with the loading machine between the crack gun's crew of different ships seems to be the order of the day in the British service. The contests are as exciting to the onlookers as to the gun's crews engaged.

Recently a gun crew from the *Glory* challenged a crew of the *Terrible*. The match was won by the *Terrible's* crew.

Crew.	Number of shell loaded into the gun.	Weight of each shell.	Time to load 20 rounds.
		<i>Pounds.</i>	<i>m. s.</i>
Terrible	20	100	1 19½
Glory	20	100	1 21½

A NOTE ON WHALE ISLAND TRAINING STATION FOR SEAMEN GUNNERS.

Telescopic sights have been fitted to all the guns at Whale Island, where 1,000 seaman gunners are continuously under training. At present the largest gun at Whale Island is the 9.2-inch, but a building is being erected for the accommodation of the 12-inch, so that before the year is out the gunners will be trained in every type of naval gun, and, with it, in the use of the telescopic sight.

INTERESTING RUSSIAN TARGET PRACTICE WITH DUMMIES.

[United Service Gazette.]

A company of infantry and a battery of artillery were each duplicated by dummy figures, so arranged that each dummy would fall over when struck by a bullet.

The infantry company fired at the dummy battery, and the battery fired at the dummy infantry company. When a dummy fell over a man was at once withdrawn from the corresponding live company.

A series of firings were carried out, one at 2,000 and the other at 800 yards. At the longer range the fire was maintained for three minutes, the company losing 84 and the battery 9 men. At the shorter range the fire was continued for two minutes, the company losing 88 men, the battery 15.

It is to be borne in mind in comparing these results that the usual proportion of artillery to rifles in the army (British) is 4 guns to 1,000 rifles, while in this practice there were 6 guns to 90 rifles.

Other experiments have been carried out with a view to obtaining more information than has been hitherto available as to the effect which may be expected to be produced by musketry fire upon floating targets, as, for instance, upon boats carrying troops for disembarkation. The principal lesson learned from the exercise would seem to have been that judging the distance of a target and obtaining the correct range is far more difficult at sea than on land. Where the distance does not exceed 1,000 yards and the sea is smooth it is possible to observe where the bullets strike the water, even when the strength of the firing party is not large, and so correct the elevation, but where these conditions do not exist the determination of the range is not so easy.

The experiments near Odessa were divided into three series. In the first, the fire was directed against targets moving parallel to the shore; in the second, against targets approaching the shore, the firing party in both cases being naturally on shore; while in the third the fire was delivered by men on board ships against a target under three conditions—namely, (a) both ship and target being stationary, (b) the ship being stationary and the target moving, and (c) both ship and target being in motion.

In the first series of experiments, against a target moving parallel to the shore, the mark was a boat such as would be used for disembarking troops filled with dummies representing armed men. This was towed by a steamer across the range, and as a uniform distance from the shore was not maintained, the number of hits obtained, considering the size and conspicuousness of the target, was comparatively few.

In the trials against the approaching mark the same target was used, but it was now attached to a cable 2,000 yards in length, the other end of which was brought ashore and made fast to a carriage to which four horses were attached. These being driven inland, the boat was drawn toward the shore at the rate of about 117 yards per minute, or 4 miles per hour, and fire was kept up on it, by volleys, until it arrived within 700 yards of the firing party. The result obtained in this case was better than the preceding, 38 per cent of the bullets taking effect. According to the Russian authorities, the experiments have shown the necessity of more extended practice of the troops, who may be called upon to oppose an attempted disembarkation, in firing under the conditions in which they would then find themselves.

REYMANN'S "CONTROL SPECTACLES."

This ingenious device, constructed by Capt. Albert Reymann, of the Austrian army, consists of a spectacle frame having a small smoked-



REYMANN'S CONTROL SPECTACLES, SHOWING AT "A" THE IMAGES OF FRONT AND REAR SIGHTS.

glass plate, entirely shut off from the light, set in diagonally. The marksman puts on the spectacles and aims, taking the line of sight through the little glass plate. The instructor, standing at his right, observes the aiming, the image of which, marked through the eye, the line of sight, and the point aimed at, is accurately and distinctly reflected in the glass. During the observation the instructor should keep as quiet as possible.

In the case of men who can not easily and firmly close their left eye, the left side of the spectacles can be darkened by a sheet-metal disk. This disk hangs in the frame and can be placed in position or removed by slight pressure on a spring.

Instruction can be successfully given at night also, in which case the point aimed at (black point or figure) is pasted on a dim disk (milk-white glass or thin paper), with a light placed behind it.

The "control spectacles" admit of strict supervision of the manner of aiming, choice of point to be aimed at, and firing, both during instruction and target practice, in every position of the body.

The ministry of war has become convinced that this apparatus fully answers its purpose and has found it to be of special advantage, as it gives the instructor an opportunity in target practice to observe the marksmen's work.

The "control spectacles" are made of substantial rust-proof material, and in order that the reflected image of the rifle or of the line of sight may appear as nearly as possible in the center of the smoked glass, the apparatus is made with high as well as low bridges to fit differently shaped noses.

The apparatus has also been tested with good results at the marksmen's school at Spandau-Ruhleben and introduced into the German army. It can be employed in connection with any modern firearm, as it is independent of the weapon, while the smoked glass immediately in front of the eye does not interfere with seeing through it, and the recoil is not transmitted to the apparatus. Finally, recruits can be made familiar with instruction in aiming by the instructor putting on the spectacles and letting the soldier observe the aiming, as shown in the annexed illustration.

Several thousand of these spectacles have been sold to the Austrian army.

TARGET PRACTICE OF THE FRENCH NORTHERN SQUADRON.

The French Northern Squadron engaged in target practice of an interesting character. The old wooden ex-*Surcouf*, which has been used as a coal hulk, was towed out by the *Infatigable* and left as a target for the squadron. The appearance of a modern vessel had been given to her by building a superstructure, funnel, and mast of light wood and canvas. Rain was falling, and there was a light haze which

partly shrouded the abandoned vessel from view, while a rather heavy swell was upon the water. The mean number of hits was estimated to be 12 per cent. The hulk was 164 feet long, with a beam of a little more than 26 feet, and the range varied between 2,000 meters (2,187 yards) and 4,000 meters (4,375 yards). The exercise lasted about a quarter of an hour, the guns employed being the main and secondary armament. At conclusion of that period of time the old hulk went to the bottom.

An examination of the report shows that in 340 rounds, 41 hits were recorded. The *Formidable* fired 74 rounds, with 12 hits, at ranges between 2,200 meters (2,405 yards) and 3,900 meters (4,266 yards), while at the same ranges the *Courbet* in 57 rounds made only 3 hits, and the *Amiral Tréhouart*, 9 hits out of 63 rounds. The estimated range for the *Bouvines* and *Valmy* was from 3,000 to 4,000 meters (3,280 to 4,375 yards), and the former in 48 rounds made only 5 hits, while the *Valmy* scored 2 out of 18. Another coast-defense armor-clad, the *Jemmapes*, fired 15 rounds, with 5 hits, and the *Dupuy de Lôme* made the same score with 65 rounds, the range in the case of the latter being 4,000 meters.

RATE OF FIRE.

The following summary of best results with heavy and quick-firing guns in the British service is given:

Best results with heavy guns.

[Target, 15 feet high; area, 525 square feet; range, 1,400–2,000 yards; speed, 8 knots.]

Ship.	Number guns firing.	Cali- ber.	Firing time each gun.	Total shots fired.	Hits.	Hits, per cent.	Per gun per minute.	
							Rounds.	Hits.
		<i>Inches.</i>	<i>Minutes.</i>					
Ocean	4	12	6	26	15	57.9	1.08	0.6
Mars	4	12	6	26	11	42.0	1.08	.46
Barfleur	4	10	6	47	23	49.0	1.96	.9
Terrible	2	9.2	6	22	14	63.6	1.83	1.16

Best results with quick-firing guns.

[Target, 15 feet high; area, 300 square feet; range, 1,400–1,600 yards; speed, 12 knots.]

Ship.	Number guns firing.	Cali- ber.	Firing time each gun.	Total shots fired.	Hits.	Hits, per cent.	Per gun per minute.	
							Rounds.	Hits.
		<i>Inches.</i>	<i>Minutes.</i>					
Terrible	12	6	2	128	102	80	5.33	4.25
Ocean	12	6	2	115	64	56	4.80	2.67
Mars	12	6	2	112	62	55	4.67	2.58
Barfleur	10	4.7	2	159	114	71.7	7.95	5.7

In prize firing, during which the foregoing records were made, the practice commenced with the guns loaded. In order to get a more accurate estimate of the rapidity of fire, the time limits in each case above should be increased by the time required to load the gun at the beginning, or the number of shots should be reduced by one and the firing time in the fourth column above reduced by the actual time necessary to fire—i. e., to discharge the first shot. This would reduce the rounds per minute to the basis of an empty gun at the command “Commence firing.” To be consistent and give credit where due, a gun loaded and ready to fire at the instant “Cease firing” sounded should be credited with a reduction in time by the elapsed time from the instant of firing the last shot to “Cease firing.”

Brassey (1902) says: “A fair way of assessing the rate of fire is to take away one round from the total of each gun and deduct from the time for the gun, half the average time between two rounds, to allow for waste at the end.”

The following table of rate of fire is given as being of interest:

Ship.	Caliber.	Number guns.	Number rounds fired.	Elapsed time.	Time one shot.	Rate fire, shots per minute.
	<i>Inch.</i>			<i>m. s.</i>	<i>Seconds.</i>	
Misaka	12	<i>a</i> 2	4	.....	40	1.5
Do.....	12	<i>b</i> 1	3	2 23	48	1.2
Formidable	12	<i>c</i> 2	10	4 56	60	1.0
Irresistible	12	<i>c</i> 2	10	4 46	57	1.0
Cressy	9.2	(<i>d</i>)	5	1 40	20	3.0
Experimental gunboat.....	9.2	(<i>d</i>)	5	1 30	16	3.7
Aboukir	9.2	(<i>d</i>)	5	1 25	15	4.0
Sutlej	9.2	(<i>e</i>)	5	1 40	20	3.0
Vickers's experimental range.....	7.5	<i>f</i> 1	5	0 37	7½	8.1

a After turret. Guns not trained on target; fired for rapidity only. Average time from command “Load.”

b Forward turret. Using one gun only, and starting with the gun empty and breech closed, just as it would be after having fired a shot, the ammunition being supplied under strictly service conditions, three rounds were fired at a target at a distance of 1,800 yards in 143 seconds. This gives an average of forty-eight seconds per round, and excellent as is the result it is only fair to add that it included delays amounting in the aggregate to no less than forty-six seconds. These delays were due in the first place to the hydraulic rammers being locked, a circumstance which was not noticed until after the trials had commenced; and in the second place to the fact that the captain of the turret temporarily lost sight of the target, owing to the approaching darkness (the hour of the trials was about 4.45 p. m., January 20. If the lost period be eliminated it will be seen that the total time of loading and firing three rounds was only ninety-seven seconds, or an average of 32.13 seconds per round. The first shot lifted the target out of the water. The second was from 10 to 20 yards over, the third 10 to the left and 20 over. The target was composed of three small buoys with red flags on the staves. Hitherto, one aimed round per minute has been considered as an excellent result from a 12-inch gun.

c Guns fired alternately; both guns empty at start.

d Service conditions. From data given, assumed to be from one gun fired as rapidly as possible.

e Same as (*d*). Fired easily three rounds per minute.

f Fired at Vickers's experimental range. Gun loaded at commencement of time limit. Stationary platform for mount. The rate of fire of this gun is said to be much accelerated by the convenience of the loading tray fitted to the gun. (See plates under “Guns and mounts”).

The following tables note some velocities and pressures of recent date:

Gun.	Weight.	Charge.	Projec- tile.	Muzzle veloc- ity.	Pressure.	Energy.	Energy per pound powder.	Powder.
	<i>Tons.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Foot- seconds.</i>	<i>Tons per sq. in.</i>	<i>Foot-tons.</i>	<i>Tons.</i>	
6-inch <i>a</i> ..	7	34	105	2,844	17.9	5,890	173	Rottweil nitrocellulose.
6-inch <i>b</i> ..	7	34	100	2,922	17.2	5,923	174	Do.
6-inch <i>c</i> ..	7	29.6	100	2,922	.....	5,923	200	Cordite.
7.5-inch <i>d</i>	15	80	200	2,903	15.9	11,700	146	Rottweil nitrocellulose.

a 6-inch, 45-caliber. Capacity powder chamber, 1,560 cubic inches.

b Same. Diameter cartridge, 6.5 inches; length, 31.2 inches; cubic contents, 1,033 cubic inches; size of gun chamber, 1,560 cubic inches.

c 6-inch, 45-caliber. Diameter of cartridge, 6.3 inches; length, 22.5 inches; cubic contents, 701 cubic inches; size gun chamber, 1,820 cubic inches. Compare (*b*) and (*c*). Difference offset by erosion of cordite.

d Vickers' 7.5-inch, 50-caliber.

MOVABLE PLATFORM FOR TRAINING GUN POINTERS FOR THE SWEDISH NAVY.

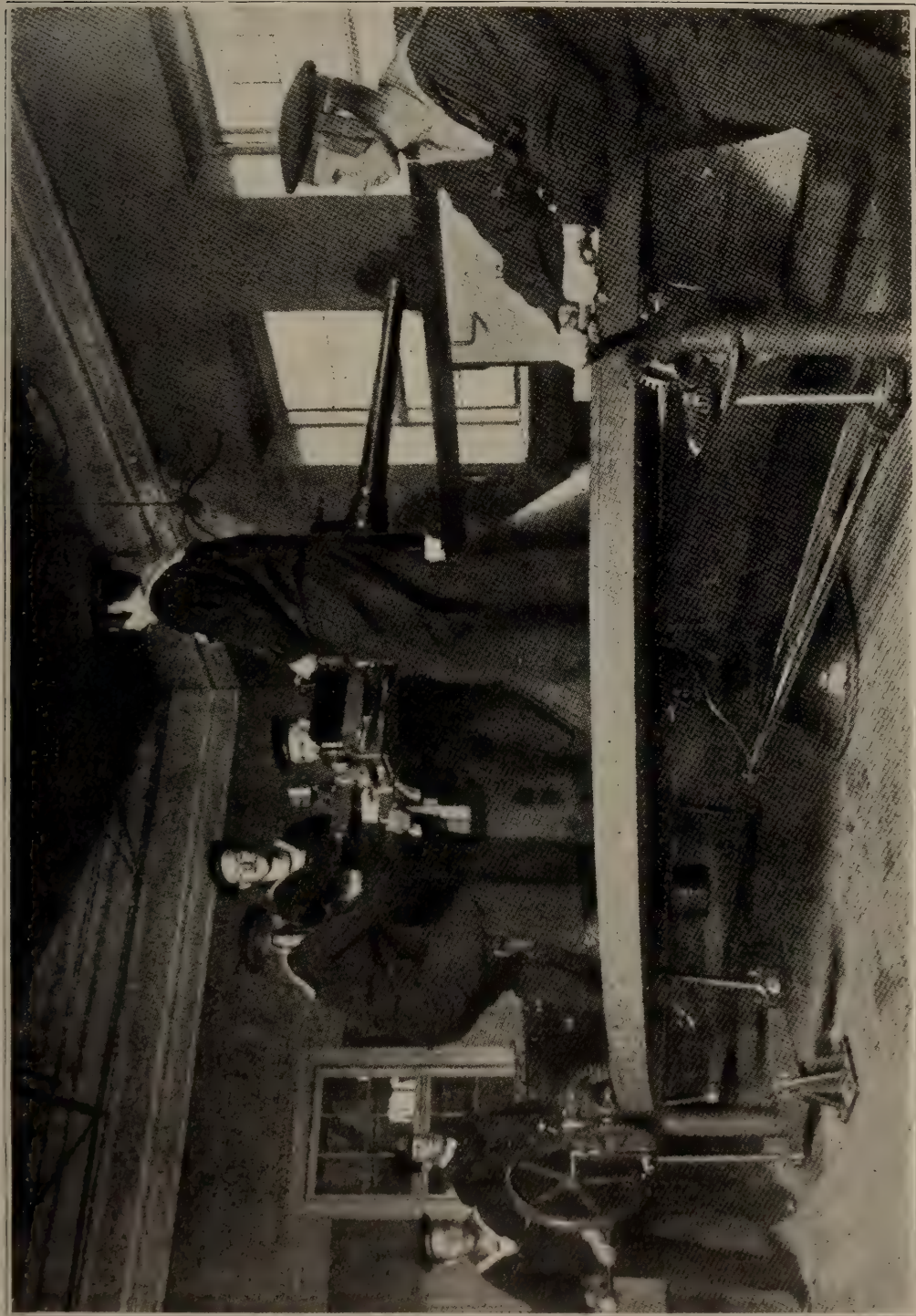
This platform is arranged in such manner that sea practice may be held anywhere without having recourse to a seagoing vessel.

When the training gear of the gun itself is employed, the dimensions of the platform and balance contrivance depend entirely on the nature of the gun to be used for the object in question.

The platform described was designed for a 5.7-centimeter (2.25-inch) R. F. gun with aiming rifle fitted thereto, with the gun crew in their usual places—that is to say, one in the rear and one on each side of the gun, besides a warrant officer on the left side of the gun.

To the floor, or deck, is screwed a cone on which the movable platform rests in a balance contrivance which permits it to move in the directions which correspond to the rolling and pitching of a ship. These two movements are effected by one or the other side of the platform being alternately raised and lowered by two levers placed under the same, which turn around a pin fastened in the floor, and which, through links and crank shafts, are connected with the platform as well as with each of its cogwheels, which belong to the stand set up on the platform, the rotation of the stand being effected by the turning of a wheel which is common to both cogwheels. Each of the aforesaid crank shafts is secured to the cogwheel by means of a screw movable from the center of the wheel and outward, whereby it becomes possible to increase or decrease the degree of rolling and pitching, as also to stop either motion entirely whenever desired.

One can thus produce either rolling or pitching alone, or both movements simultaneously, up to 7 or 8 degrees, which is probably more than would be required. Moreover, as the rolling movements of the platform, which are the result of the direction of the eccentricity



MOVABLE PLATFORM FOR TRAINING GUNNERS IN THE SWEDISH NAVY.

which produces the same, are somewhat more rapid after the horizontal position is passed, the motions of the platform are as nearly like those of the deck of a rolling ship as could be desired.

In order to illustrate the relation of the line of sight to the target when the latter is moving and when the ship from which the firing takes place is under way, the target is adapted to move laterally at any desired speed. One may also illustrate with the movable platform the conditions which arise when the ship, owing to a seaway, rises and falls, by making the course over which the target moves undulating.

If it is desired to illustrate still more graphically the yawing or running of the ship, the platform described can be supplemented by a yawing contrivances, which require some modifications. The balance device is removed from the cone screwed to the floor and secured to a pivot which is movable, in the cone, by means of ball bearings. According to the degree of rotation which it is desired to give to the platform—i. e., the yawing movement which it is desired to produce—without affecting the rolling and pitching motions except in a very slight degree, the aforesaid pivot is raised and with it the platform, besides which the links connecting it with the levers are lengthened.

A link 35 centimeters (13.78 inches) long admits of an angle of rotation of 9.5 degrees, while the inclination given the platform as the result of the rotation does not exceed 1 degree at the extreme edge where it is greatest. The yawing motion is effected by the movement of a wheel belonging to the smaller stand and which, by means of gearing, drives an eccentric disk, whereby a forward and backward movement is imparted to an arm secured to the pivot upon which the platform rests.

When the yawing contrivance is used, or when the platform is set up on board a training ship which can be given a yawing motion, it is not necessary to have the target move sideways in order to illustrate the yawing or running of the ship. Nor is this necessary when the target is within the proper distance for subcaliber practice, namely, about 15 meters (49 feet), unless the target can be placed far enough from the gun to make it practicable to use the ammunition of the aiming rifle, whereby target practice at a distance within the range of the aiming rifle becomes possible.

The wheel belonging to the larger stand can be easily turned by one man, and the rapidity with which it is turned must be such as to give the platform a rolling motion corresponding to the rolling periods of the vessel from which the firing is supposed to be done. The platform should not be used unless the requisite number of men are in their proper positions thereon, as heretofore indicated, in order that the wheel may be turned evenly and with the least possible wear and tear to the material.

GUN TRIALS OF H. M. S. FORMIDABLE.

The new first-class battleship *Formidable* carried out her gun trials at Portsmouth. Five rounds were fired from the two 12-inch guns in the fore turret and seven were fired from the after turret. Six of these rounds were fired in salvos of two each in 144 seconds, starting with loaded guns. The machinery, all of which was designed and supplied by Sir W. G. Armstrong, Whitworth & Co., of Elswick, worked without a hitch throughout the trials. As far as the hydraulic machinery for working the 12-inch guns is concerned, the *Formidable* is the first of a class which includes the *Implacable*, *London*, *Bulwark*, *Duncan*, *Cornwallis*, *Russell*, and *Queen*, and therefore the trials which took place were of much importance. The last two ships to be completed were the *Albion* and the *Glory*, and they stand alone in the design of their hydraulic gun machinery.

Besides having an improved design of machinery, the *Formidable* carries 12-inch guns of greater power than her predecessors, for, though the projectile is of the same weight, it is given a higher velocity, which is due to a larger cordite charge. In the *Glory* and *Albion* the ammunition was brought from the magazine through a long trunk direct to the breech of the guns but, in the *Formidable* a beak or projection is made at what is known as the working chamber. This chamber is under and attached to the turntable, and the object of landing the ammunition there on its way to the guns is to make the final hoist as short and therefore as quick as possible. The supply of ammunition from the shell room and cordite magazine to the working chamber thus goes on independently of the firing of the guns, and there is therefore always a charge, or even two charges, ready for each gun. The moment a gun is fired it is run out after a recoil of 33 inches and put into the loading position, which is at $4\frac{1}{2}$ degrees of elevation. The loading angle for 12-inch or larger guns has previously been $13\frac{1}{2}$ degrees. At the same time as the gun is run out the breech is opened by hand, and then, by the movement of a lever, the 850-pound shot and the cordite charge are made to rise up from the working chamber to the gun. Another lever causes the chain rammer, which is a further new departure, to ram home first the shot and then the charge. The empty ammunition cage then disappears again into the working chamber, the breech is closed by hand, and at the same time the gun is elevated again as desired.

THE BULWARK'S GUN TRIALS.

The principal trials were those of the 12-inch (50 ton) breech-loading guns. These guns, of which the vessel carries four, two in each turret, are of the newest type, known as the Mark IX, and for this reason special interest is centered in the trials. Six rounds were fired from the fore turret at various degrees of elevation and at bearings

ranging from right abeam to right ahead, the right and left guns of the turret being fired alternately for the first four rounds, while the last two rounds were fired by both guns simultaneously. The first two rounds were fired with charges of cordite, each weighing 158 pounds, and the remaining rounds with the usual full charge of 211 pounds of cordite, the projectile in each case weighing 850 pounds. Some of the tests were of an exceptionally severe character, and especially one with a full charge, when the gun was fired at no less than 4 degrees of elevation. With the gun in this position the shock of the discharge is calculated to disclose any weakness in the construction of the vessel or any defect in the turret or its surrounding fittings. The after turret was then subjected to similar trials, and then in turn the quick-firing and machine guns and the torpedo armament were tested. Before the *Bulwark's* return to harbor a careful survey was made, and, contrary to former experience, not a single stanchion or frame was found to be in the slightest way crippled; the only damage done was the breaking of a few panes of glass in the cabins immediately under the after turret.

GUN TRIALS ON H. M. S. "IRRESISTIBLE."

[From The Times, October, 1901.]

The gun trials of the *Irresistible*, battleship, which took place at Portsmouth, have been looked forward to with considerable interest in naval circles, as this is the first ship in the service fitted with the new type of Vickers's *mounting, by means of which heavy guns can be loaded in all firing positions*, whether of training or elevation. The *Irresistible* is a first-class armored battleship of 15,000 tons displacement, with propelling machinery of 15,000 I. H. P., and has recently concluded her steam trials in the North Sea. She was built at Chatham, and her main armament consists of four 12-inch Vickers Mark IX guns, mounted in pairs forward and aft in armored redoubts. The revolving platform carrying the guns is protected by an armored steel hood 8 inches thick, but sloped to such an angle as to give the same protection as would be secured by armor of twice this thickness. Each 12-inch gun weighs slightly over 50 tons, and fires a projectile of 850 pounds with a cordite charge of 203 pounds, giving a muzzle velocity of 2,600 feet per second. The muzzle energy of the projectile is 4,028 foot-tons.

The guns are mounted independently in pairs on a revolving platform, and can be manipulated by both hand and hydraulic power gear. The chief innovation in this gear is the introduction of a new feature of a comparatively simple nature which enables the gun to be loaded at any angle of elevation, thus obviating the necessity of bringing the gun to a fixed position for loading between the rounds, while in accordance with the now universal practice in all new ships the guns can be loaded in all positions of training. The adoption of the method

of loading at any angle of elevation therefore completes the improvement which was begun when the fixed horizontal position for loading was abolished, so that now guns can be loaded in any firing position, thus avoiding not only the loss of time involved in bringing the weapon to and from a fixed position of elevation, but what is of very great importance the gunner is enabled to keep his sights constantly on the object he is aiming at. Thus the means are furnished both of rapid fire and accurate aim.

The redoubts of the *Irresistible*, which are circular, are protected by 12-inch armor. The turntables revolve on a live-roller ring carried on a ring bulkhead, supported independently of the redoubt structure, so that considerable distortion of the latter will not affect the working of the guns. A working chamber is attached to the underside of the turntable and revolves with it. From this chamber a trunk descends to the shell rooms and magazines and serves for the passage of the ammunition from the latter to the chamber, where it is transferred automatically from cages in the trunk to cages working between the base of the chamber and the gun platform. These cages are so arranged that the projectile is always in line with the bore of the gun when it is raised sufficiently to abut against stops carried on the oscillating part of the gun mounting. The projectile can then be rammed home by a chain rammer, which is also carried on the gun mounting. This rammer, being flexible in one direction and rigid in the other, can not consequently buckle up when being extended. It is operated by the revolving of a sprocket wheel, to which it is geared, the tail end of the chain being supported conveniently in a casing carried below the gun slide. The rammer is provided with a safety apparatus so arranged that it can not be worked until the cage is in the loading position, while the latter can not be lowered until the rammer has been withdrawn. For hand loading the rammer head can be lowered in rear of the bore of the gun, and the projectile, which is carried on the telescope bogie, can, after being pushed forward on it, be rammed home by an ordinary rammer stave.

The trials were carried out under the supervision of the experimental staff of the *Excellent*. The usual number of rounds was fired from the forward turret with practice and service charges, and diagrams of pressure and velocity were taken from the recoil cylinders of both guns. These were in accordance with the design, the recoil being practically 33 inches with the full service charges. In the after turret an elaborate programme of speed firing was carried out to test fully not only the new method of loading the guns at all firing angles, but the accuracy of fire obtainable under the new conditions. For this purpose a small target was launched overboard, and with the ship steaming at a distance of about 1,200 yards fire was opened with both guns, each of which fired 5 rounds alternately. The result was satisfac-

tory, as every shot would have hit the side of a ship in the vital parts, while the 10 rounds were fired in four minutes and forty-six seconds. The crew had only had three days' practice with a type of machinery that was new to them, and it may therefore be reasonably assumed that even better results will be obtained with a practiced crew. After the trials the mountings were carefully examined and were found to be in good order, no hitches of any kind having occurred.

GUN TRIALS OF H. M. S. VENGEANCE.

The new first-class battleship *Vengeance* carried out her gun-mounting trials at Portsmouth last October after several daily postponements in consequence of the fog. The *Vengeance* is the first battleship built by Messrs. Vickers, Sons & Maxim, and is also the only ship in the British navy which has been built, engineered, armored, and supplied with her heavy gun mountings by one firm. She was ordered twelve months later than her five sister vessels, the *Canopus*, *Goliath*, *Ocean*, *Albion*, and *Glory*. The chief difference, however, between the *Vengeance* and her predecessors of the *Canopus* class is the type of heavy gun mounting by means of which the 12-inch guns can be loaded at all firing positions, whether of training or elevation. The *Vengeance* is also the last ship to be supplied with the Mark VIII Woolwich guns of 46 tons and 36 calibers in length, which, though not so powerful as the Vickers Mark IX of 40 calibers, is still a formidable weapon, as it fires a projectile of 850 pounds in weight with a muzzle velocity of 2,367 foot-seconds and a muzzle energy of 33,000 foot-tons. A complete broadside from the *Vengeance* would bring into action four 12-inch, six 6-inch, six 12-pounder, and six Maxim guns. These 22 guns would fire at one time 11,000 pounds of metal with a collective energy at the muzzle of over 600,000 foot-tons. An important advantage afforded by the new mounting is that, while the gun can be kept sighted on the object aimed at, the gear is simplified rather than complicated, as there are no locking bolts nor apparatus for working them. All the loading operations are carried out by hydraulic power, but simple fittings have been provided for the use of hand power as an alternative. In the forward turret 3 rounds were fired from each gun with practice and service charges from 10 degrees before to 10 degrees abaft the beam. The last two rounds were fired simultaneously, one gun being at the maximum depression and the other at the maximum elevation, but no damage was sustained beyond the breaking of a few glass fittings. In the after turret 4 rounds were fired from each gun to ascertain the maximum rate of fire obtainable with the type of loading gear, but the conditions of firing were a slight modification of those observed in the *Irresistible*. The results were regarded as highly satisfactory, as it was shown that with a trained crew and the machinery operated under ordinary working conditions

a rate of 2 rounds a minute could be maintained for a prolonged period.

Before the testing of the heavy gun mountings all the small weapons were subjected to the trials, with satisfactory results.

H. M. S. ABOUKIR.

In the trials of the *Aboukir's* 9.2-inch guns, 5 rounds were fired from one gun in eighty-five seconds. Weight of projectile, 380 pounds; weight of cordite charge, 52 pounds. The firing commenced with the gun empty and the breech closed.

SECTION V.

EXPLOSIVES.

CORDITE IN THE BRITISH NAVY.

In the spring of 1900 the war office and the Admiralty agreed to appoint a committee for the purpose of examining the whole question of service explosives with a view to remedying, if possible, some of their admitted defects. Soon after the commencement of the Boer war it was discovered that the British service explosives—cordite and lyddite—were not as satisfactory as could be wished. Cordite was found to be eroding the larger field guns and naval guns, while lyddite proved to be by no means so formidable as was supposed in some quarters, and to be very capricious in its action. With a view to still further developing the power of the new service ordnance by way of improving the propelling agent, a committee was appointed to carry out trials with the object of ascertaining what were the best smokeless propellants for use in existing guns of all natures and in existing small arms. The committee was to report as to whether or not any modification in the existing designs of guns was desirable, with a view to developing to the full the power of any propellant which might be proposed.

NEW SMOKELESS POWDER.

One of the first acts of the explosives committee was to draw the attention of the manufacturers of propellants and high explosives on the home office lists to the work it was proposed to carry out. A letter was sent out inviting manufacturers to put forward for trial any propellants or high explosives which, in their opinion, gave reasonable promise of proving more efficient than the existing service article. All trials of explosives would be treated as confidential, and the manufacturing departments of the Royal ordnance factories would not have access to any powders which might be put forward for the purpose of experiment. The explosives committee has now been at work for more than a year and a half. During this period it has tested a large number of explosive compounds, and has carried out many experiments. The result of the committee's deliberations has been that a

new service propellant has been evolved, which will shortly be introduced into both services. This new smokeless powder is known by the name of "Cordite M. D." As its name implies, it is a modified form of the present service explosive, and it is believed by the committee to be a powder better suited for guns than cordite itself.

"Cordite M. D." is now being manufactured, and if it turns out to be as satisfactory as the committee anticipates it will gradually replace cordite as the propelling charge, at any rate in the larger field pieces and naval guns. "Cordite M. D." has a nitrocellulose base. Cordite (so named from its cord-like appearance) was patented in 1889 by Sir Frederick Abel and Professor Dewar, and was adopted as the service propellant in 1890. Its composition is as follows:

	Per cent.
Nitroglycerin	58
Trinitrocellulose, with a small proportion of soluble gun cotton	37
Vaseline	5

The composition of "Cordite M. D." is, of course, an official secret, though it will doubtless be found impossible to prevent the ingredients and their exact proportions becoming known. Its base, as already stated, is nitrocellulose, and it is believed to contain a certain percentage, not more than 30, of nitroglycerin, but not nearly so high a percentage as cordite. The temperature of explosion of cordite is practically double that of nitrocellulose powder, owing to the large amount of nitroglycerin, a substance which on explosion generates a high degree of heat. This naturally has a serious effect on the bore of the gun. The wear of the bore at the beginning takes the form of erosion of very fine lines, which develop as the rounds are continued, completely washing away the surface, and enlarging the seat in the gun where the shot is rammed home. The pressure is diminished, the energy is reduced, the velocity is lowered, shooting becomes erratic, and finally the gun has to be sent away to be fitted with a new inner tube. Were it not for its erosive effects cordite would be the best propellant in the world. It is cheap, its keeping qualities are excellent, and it is really smokeless.

The effect of cordite can be best illustrated by the careful records which are kept at Woolwich Arsenal of every gun in the navy and army, a complete biography of its manufacture, the number of rounds fired, the effect produced on the weapon, and the repairs carried out from time to time. As an instance it may be mentioned that a 12-inch 50-ton gun, owing to the deleterious results caused by cordite, has its life at an end after about 100 rounds have been fired. Then it has to have the inner tube, that which takes the rifling, replaced.

Official notification of the change in the composition of cordite has been made to contractors who supply the Government with ammuni-

tion. The charges with the improved cordite for the various service weapons will be as follows: 4.7-inch quick-firing gun, 5 pounds 7 ounces; 12-pounder quick-firing gun, 1 pound 10 ounces; 6-pounder, 7 $\frac{3}{4}$ ounces; 3-pounder, 6 $\frac{2}{3}$ ounces, and the 0.303 service rifle, 30 grains.

It is stated that "Cordite M. D." is not satisfactory to the British naval authorities and has not been generally adopted for naval guns, but is being adapted to only one, probably the 6-inch. The full advantages of the pure nitrocellulose powders are doubtlessly recognized by the British naval authorities, but the small chambers of the British guns, already in service, preclude the advantageous employment of powders containing no nitroglycerin.

EXPLOSIVES OF FOREIGN POWERS.

"Cordite M. D." will probably be found dearer and bulkier than cordite, but its freedom from erosive effects will make it the more valuable powder of the two. An expert recently said: "Nitrocellulose powder has the great advantage of being capable of producing in modern artillery the highest possible ballistics with the least possible amount of wear to the gun." This accounts for the fact that Russia, France, and Germany have all adopted some form or other of nitrocellulose powder. The French service powder, known as "Blanche Nouvelle" or "B. N.," consists of nitrocellulose, partly gelatinized and mixed with tannin, barium, and potassium nitrates. Germany has now adopted a nitrocellulose powder, though until lately she used a form of nitroglycerin explosive.

WET GUN COTTON AS THE BURSTING CHARGE FOR SHELL.

Naval and military authorities have for years past been, and are still, occupied with the question of high explosives as the bursting charge for shell. Wet gun cotton is known to be, in its wet state, a perfectly safe, unflammable, and inert explosive in the absence of a detonating force. The only obstacle to its general use for shell purposes hitherto has been the circumstance that to insure complete detonation a primer of dry gun cotton and a fulminate of mercury detonator have been required, and both of these agents are too sensitive to premature ignition by friction heat or concussion to permit their employment under the conditions of shell firing at the present day, owing to the high pressures and great velocities attained with modern artillery.

The means, therefore, of adapting the wet gun cotton successfully for general shell work has long been sought, and after many years of experiment and research, the New Explosives Company, of London, have placed before the war office a new safety exploder, the composition of

which contains neither dry gun cotton nor fulminate of mercury, but which will detonate wet gun cotton with certainty under the safest conditions. The composition itself will not detonate under a temperature of 360° C., and can not be ignited by friction or shock, but at the same time is brought instantaneously into action with an ordinary detonating pellet such as is commonly employed in all percussion or time fuses of general service to-day. The force then exerted will detonate in its turn any charge of wet gun cotton, without leaving any traces of unburnt explosive or residue. The composition is very stable and stands an excellent heat test, and it is not affected by any climatic changes, and in cost of manufacture it is less than gun cotton.

The main bursting charges were made by the company's new method of forming and compressing wet gun cotton, whereby it is now possible to produce charges of compressed gun cotton in one whole solid block of any dimensions, mechanically true, and of theoretical and uniform density throughout.

With the old method of work certain practical difficulties have prevented the direct formation of "shaped" blocks such as are required to form the bursting charges for shell and for torpedoes, and it has hitherto been the practice to build up such a charge from a number of disks, and to reduce them to the required shape and size in a lathe. By the new process such charges can be formed in a single block without any subsequent turning or other shaping being necessary.

There is no space wasted, as is the case with built-up charges through slightly imperfect contact between the individual blocks, and thus either a heavier charge (i. e., about 15 per cent more gun cotton) can be got into the same space, or less space will be occupied by a charge of given weight. The following experiments by Armstrong, Whitworth & Co. were made on April 8, 1902.

The first experiment consisted of firing ten rounds from a 6-pounder quick-firing gun. The total weight of each shell as fired was 5 pounds $10\frac{1}{2}$ ounces, the weight of the wet gun cotton bursting charge being 100 grams and that of the explosive in the safety exploder 9 grams.

The shell was fitted with the ordinary Hotchkiss fuse, Mark IV. The target was a three-fourths-inch steel plate at a range of about 150 feet. In the rear of this were two heavy steel coils, forming a cell 7 feet long, backed by a 12-inch plate, to confine the fragments, which were afterwards collected, counted, and weighed. The propellant employed was ordinary Government cordite, service charge, $7\frac{3}{4}$ ounces. The following table describes the fragmentation of the shell and the chamber pressures and muzzle velocities for each round:

Rounds.	Chamber pressure.	Muzzle velocity.	Recovered of shell.		Recovered of brass.		Recovered of gas check.		Largest piece recovered.	Total weight of shell recovered.	
			Pieces.	Lbs. oz.	Pieces.	Lbs. oz.	Pieces.	Lbs. oz.		Lbs. oz.	Lbs. oz.
First	(a)	(a)	102	4 4	7	0 1 $\frac{3}{8}$	3	0 $\frac{1}{8}$	0 4	4 5 $\frac{1}{4}$	
Second.....	(a)	(a)	143	3 15	14	0 $\frac{5}{8}$	9	0 $\frac{1}{4}$	0 8 $\frac{3}{4}$	3 15 $\frac{7}{8}$	
Third	11.28	1,800	67	3 9	14	0 $\frac{3}{4}$	.....	None.	0 3 $\frac{1}{2}$	3 9 $\frac{3}{4}$	
Fourth.....	12.26	1,827	104	4 4 $\frac{1}{2}$	6	0 $\frac{3}{4}$	.....	None.	0 6 $\frac{5}{8}$	4 5 $\frac{1}{4}$	
Fifth.....	12.39	1,838	154	4 2	10	0 1 $\frac{7}{8}$	6	0 $\frac{1}{4}$	0 6 $\frac{7}{8}$	4 4 $\frac{1}{8}$	
Sixth	(a)	(a)	135	3 14 $\frac{1}{2}$	8	0 1	.....	None.	0 6 $\frac{1}{8}$	3 15 $\frac{1}{4}$	
Seventh.....	(a)	(a)	84	4 3	10	0 $\frac{3}{4}$	.....	None.	0 7 $\frac{1}{2}$	4 3 $\frac{1}{4}$	
Eighth.....	(a)	(a)	222	4 3 $\frac{3}{4}$	9	0 $\frac{5}{8}$	.....	None.	0 7 $\frac{3}{4}$	4 4 $\frac{1}{8}$	
Ninth.....	(a)	(a)	306	8 6	31	0 2 $\frac{1}{2}$	.....	None.	0 6	8 8 $\frac{1}{2}$	
Tenth.....											

a Not taken.

The second experiment was the bursting of a 6-inch shell at rest. This was done in a closed cell of wrought iron 7 $\frac{1}{2}$ inches thick by 3 feet 6 inches in diameter by 5 feet deep, weighing 6 $\frac{1}{2}$ tons, from which none of the fragments could escape, the main object in this instance being to demonstrate that the wet gun-cotton charge and safety exploder would act equally satisfactorily without the assistance of the shock of impact at a short range, and detonate as instantaneously and energetically (1) as if fired from a gun, and (2) in large as well as in small quantities. The force of the explosion burst the coil open. There were no traces of unconsumed explosive. The fragments recovered numbered 2,122 pieces, the largest weighing 10 $\frac{1}{8}$ ounces, and the total 65 $\frac{1}{4}$ pounds.

The shell was an ordinary cast-steel one, weighing, fully loaded, as fired, 119 $\frac{1}{2}$ pounds.

The wet gun-cotton charge weighed 6 pounds 9 ounces, and the explosive composition in the safety exploder 300 grams. The fuse employed was of the ordinary service direct-acting pattern, and was fired electrically.

Before the trials commenced it was convincingly proved that the gun-cotton charges contained the usual amount of moisture, viz, about 18 per cent of water, and that there was no dry gun cotton or fulminate of mercury employed in the composition of the safety exploder, and in view of the very excellent results obtained it seems highly probable that gun-cotton shell charges will become more generally employed, especially in armor and deck piercing projectiles. With a delay action fuse, wet gun cotton, with this new safety exploder, it is claimed, can be fired through the thickest armor plate that the shell itself will penetrate without exploding until it has passed through.

THE MANUFACTURE OF GUN-COTTON CHARGES.

[From Engineering.]

The New Explosives Company, Limited, have recently introduced a new method of compressing gun cotton for charges of locomotive

torpedoes, shells, submarine mines, etc. By this system it is possible to produce charges of gun cotton mechanically true and having uniform density throughout the block. The density depends upon the percentage of moisture, the amount of which can not only be accurately determined, but is uniformly distributed throughout the mass, even in blocks of largest size. In this way the charge for each war head of an 18-inch Whitehead torpedo can be compressed in one block. This is a new departure, as hitherto large charges have been built up of smaller parts. Up to the present the practice has been to make blocks of no greater thickness than 2 inches or of greater weight than 8 or 9 pounds.

In fig. 1 is shown, for the sake of comparison, a torpedo charge for an 18-inch Whitehead torpedo opened out. This will illustrate the method of assembling gun-cotton blocks hitherto practiced.

Through the courtesy of the New Explosives Company was recently had an opportunity of seeing their machinery in operation. The process of manufacture is described. It may be said, briefly, that the new features introduced are, first, the working up of gun-cotton pulp in such a manner that air is completely expelled from the mass, which is worked together so as to produce a strong and homogeneous block; secondly, large masses of gun cotton can be compressed, owing to certain safety devices which have been introduced into the hydraulic machinery and which will be presently described.

Fig. 2 gives an elevation, partly in section, of the apparatus used in the first process, it being understood that the gun-cotton pulp has been already prepared in the usual way. When it is afterwards pressed to form the charge, if air is not removed, the cavities in which it rests are naturally made smaller by pressure; but when the pressure is removed they expand again, rendering the block spongy or laminated. The consequence of this is that detonation is often not complete when the charge is fired. To get over this difficulty, the gun-cotton pulp is introduced into a vertical cylindrical vessel. Descending into this is a vertical shaft, as shown, at the extremity of which is a screw similar to a marine propeller. There are also certain projections which are known as agitators. The latter are attached to a sleeve which surrounds the vertical shaft, and they are therefore free to rotate independently. The motions are obtained by belts and pulleys in a manner clearly shown in the illustration. In addition to the rotatory motion of the propeller, it is also given a reciprocating movement by means of a lever situated above the belts on the pulleys. The lever is caused to reciprocate by means of the cam, which is fixed to the revolving shaft that actuates it. The whole of these three motions are obtained by means of friction gear, as indicated in fig. 2. The cylinder containing the pulp is placed on a table, which rises and falls as may be desired. The method of operation is as follows: Pulp in a

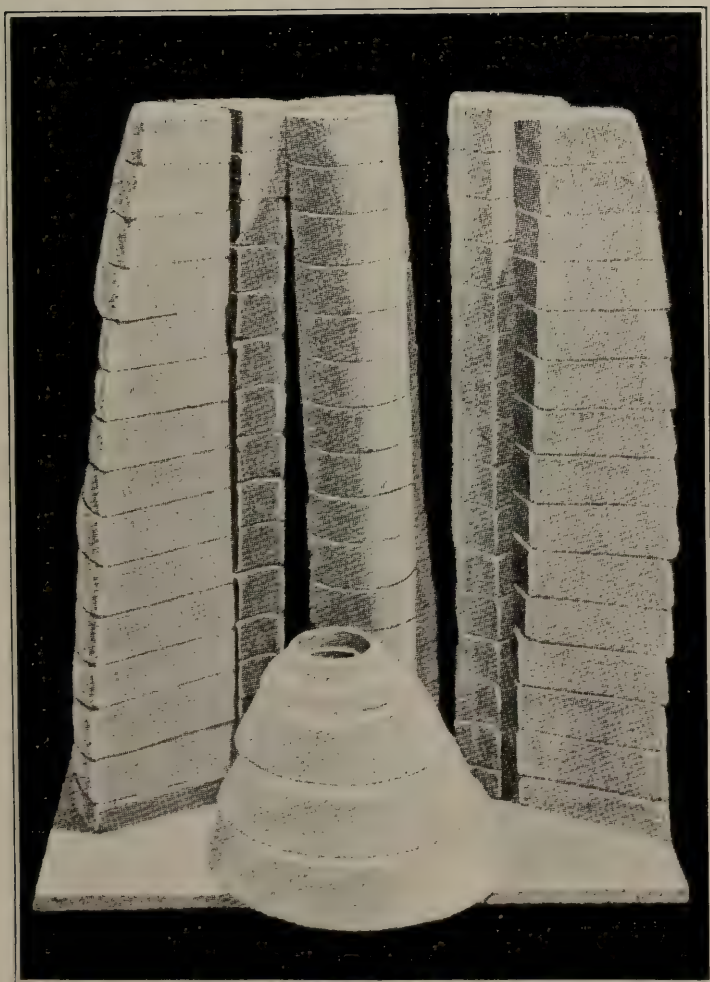


FIG. 1.—BUILT-UP CHARGE FOR WHITEHEAD TORPEDO (18-INCH).

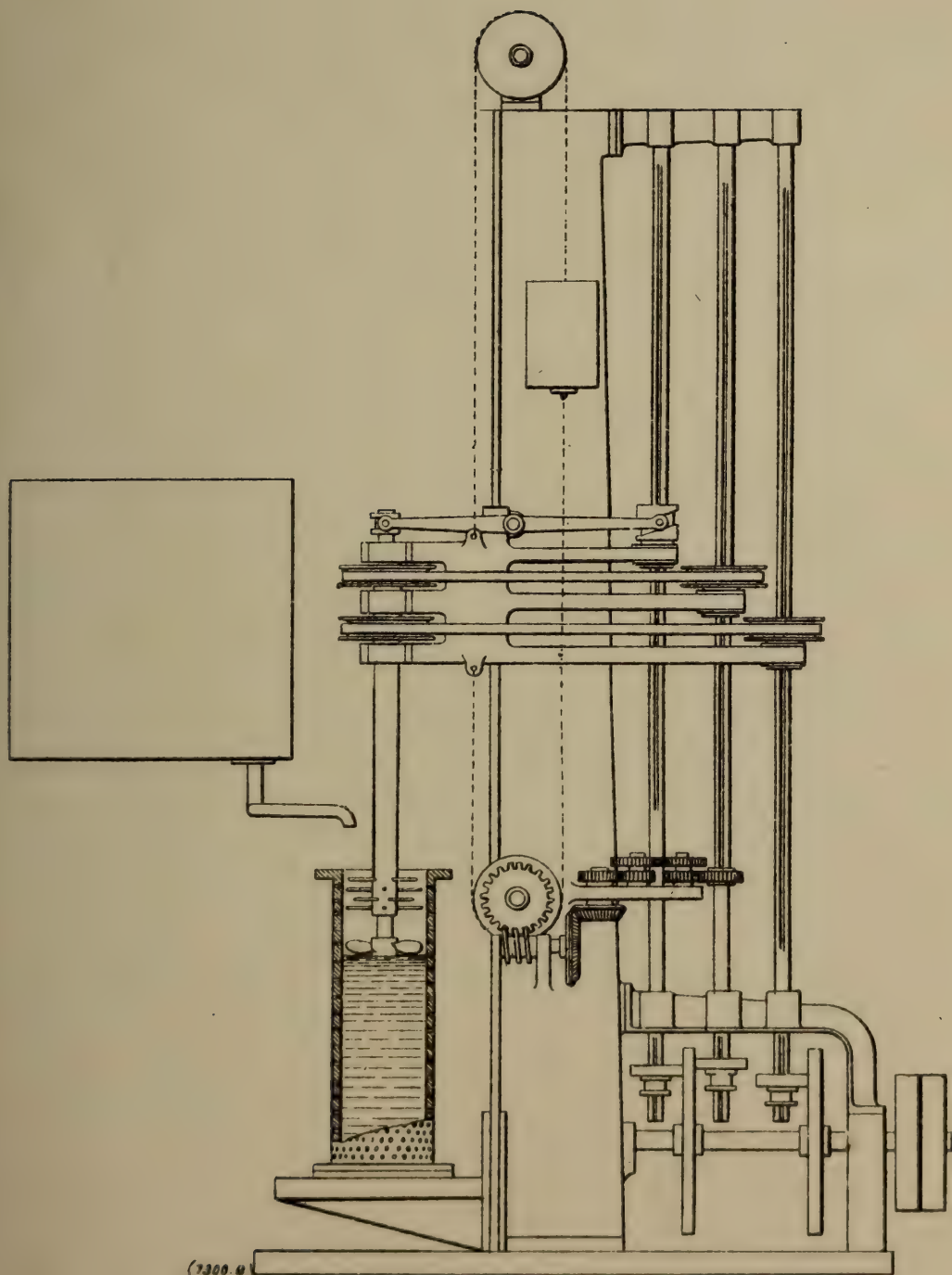


FIG. 2—PULP DISTRIBUTOR.

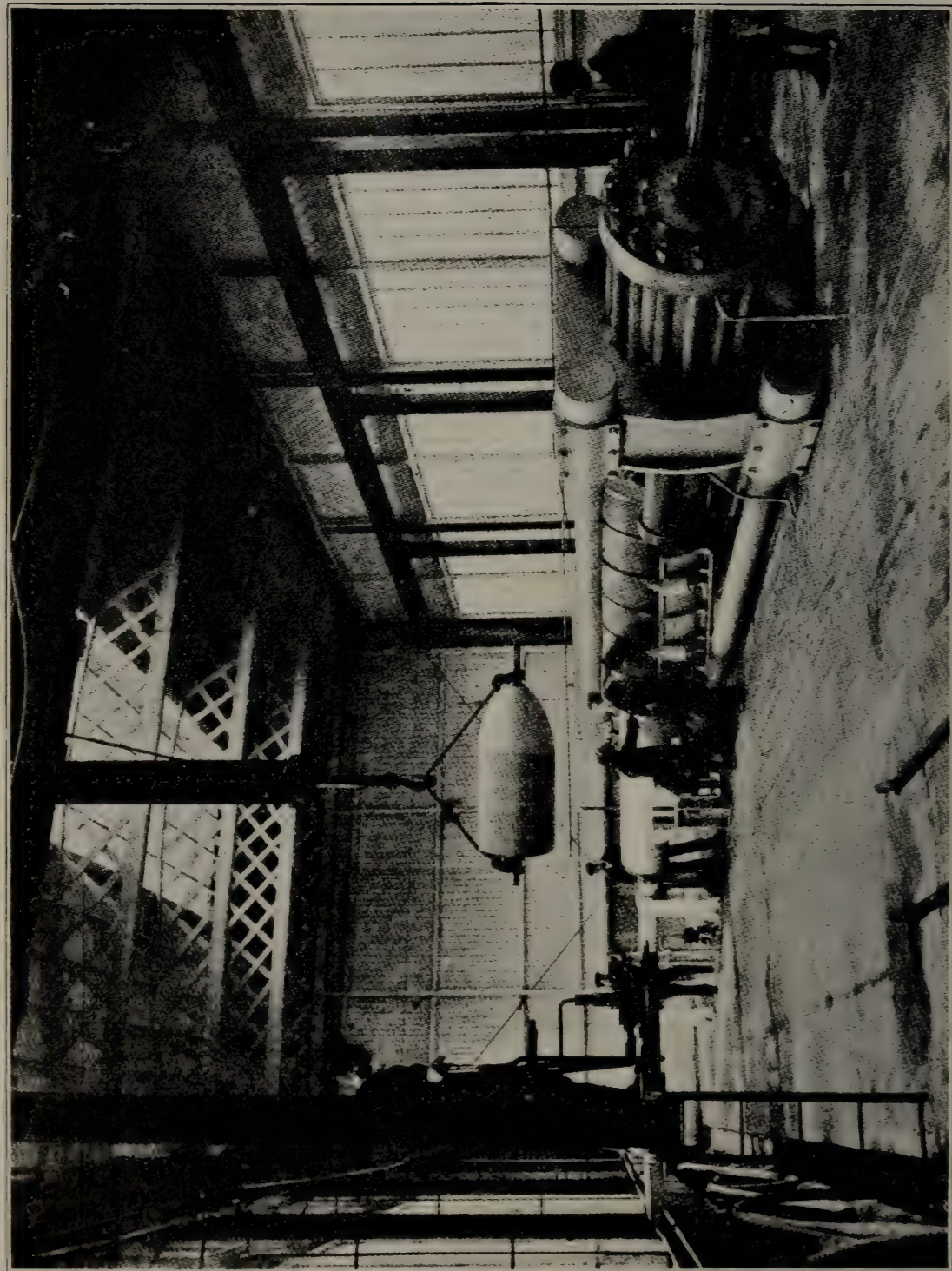


FIG. 3.—HYDRAULIC PRESS AND CRANE.

very liquid state is admitted into the perforated cylinder, and the machine is set to work. As the screw revolves, and rises and falls at the same time, it presses and beats the pulp. Water drains away through the perforations in the cylinders, and carries air with it, the action being very similar to that of squeezing a sponge. The perforations are, of course, fine, so that the gun cotton does not pass away with the water. The fibers of gun cotton by this process are uniformly placed into position, so that the hydraulic pressure does not exert undue pressure upon any particular part, on account of either air or uneven masses of gun cotton. The molded gun-cotton blocks vary according to the size of the torpedo, mine, or shell to be manufactured; it is therefore necessary for the cylinder containing the molded charge to be on a table with perpendicular travel. As the charge forms, the table slowly leaves the revolving screw; nevertheless the same pressure and even distribution of the pulp is preserved throughout its entire length. When forming an 18-inch Whitehead torpedo a molded charge of about 9 feet long is required. Latterly there have been some alterations in the form of the cylinder, which is now made of perforated sheet-metal, and is contained in an outer cylindrical casing. The water flows into the annular space between the casing and the cylinder and runs over at the top, carrying the air with it.

Once started, the operations have to be continuous. Should a break occur in the operations, say through the failure of a belt, or from any accident of that nature, and the working were started again, there would be a plane of cleavage in the gun-cotton block. This would be likely to cause it to break at that part. In the event, therefore, of any accident happening, and the machinery stopping, the pulp has to be returned to the factory and worked up again.

The new press by which these large charges are formed, and which is illustrated in figs. 3 to 12, is described in the following: The mass of gun cotton is placed in a perforated container, which is shown in longitudinal section in fig. 9, and in cross section in fig. 10. This container is carried by means of rings in an outer holder, there being between the two a space into which water under pressure can be introduced through a pipe (shown), to prevent the gun cotton entering the perforations, and also to act as a lubricant when the mass has to be forced out of the container and into the mold or die, shown in figs. 7 and 8, in which it is finally pressed into a charge for torpedo or shell as may be required. The container, with the gun cotton in it, is placed on a cradle or support, which is fixed at an angle to the center line of the press, as shown in figs. 3 and 4. It is now required to transfer the mass of gun cotton from the container to the mold or die of the press. For this purpose the mold is mounted on a carriage, which in turn rests on a swiveling device and ball bearings. The

latter are carried in a block movable on slides, and the mold can thus be turned so that it is in line with the fixed support on which the container is placed. This is the position shown in fig. 3. The container and the mold being coaxial, a hydraulic ram, situated at the back of the container, will be able to push the charge from the latter into the mold. The latter are illustrated in figs. 7 and 8, the former being a longitudinal section and the latter a cross section on the line B. It has an inner lining, divided longitudinally into two or three pieces. Outside this is a thicker jacket, which is also divided longitudinally, but into a greater number of parts; and beyond this, again, is the still thicker outer casing, which is wound with wire, as shown, to give it additional strength. The interior surface of the outer casing and the adjacent exterior surface of the jacket are conical, so that when the pieces of the jacket are moved endwise the pieces of the lining are wedged together so as to form tight joints. There are perforations in the lining and jacket, as shown in figs. 7 and 8, and these open into passages formed as annular channels between the jacket and the outer casing. These are provided so that water may readily escape from the charge during the process of compression. These passages are all connected together by lateral openings, shown in fig. 8. These openings in turn communicate with a pipe leading into a tank, the arrangement being such that if the charge should expand when pressure is released, water will flow back to be absorbed, instead of air being drawn in.

The mass of gun cotton having been pushed into the mold by the ram at the back of the container support, the mold is turned with its carriage so as to be in line with the two rams of the press, there being one at each end, as shown in fig. 4. The end of the jacket and lining are slightly projecting, and rest against the head of the ram which is at the end of the press at which the charge was introduced—that is, the end farthest from the spectator in fig. 3—while the end of the outer casing rests against an annular ring carried on the head or face plate of the same ram. The ram at the opposite end is caused to advance, and the other ram also pushes the mold toward it, the carriage on which the mold is supported sliding for the purpose. This presses the mass of gun cotton in the mold to the desired extent. The near ram (fig. 3) is then withdrawn, and an annular head is attached, which bears only against the end of the casing. The ram at the narrow end of the wedges has an annular groove upon the face plate, which enables this ram to exert pressure against the pressing cylinder with the safety-head ram against the gun-cotton charge without moving the wedges. When the wedges are to be released a ring is put inside this annular groove; this enables a longitudinal displacement of the wedges of about 2 inches to be effected, when all is loose, and the face plate is flush with the face of the pressing cylinder. The

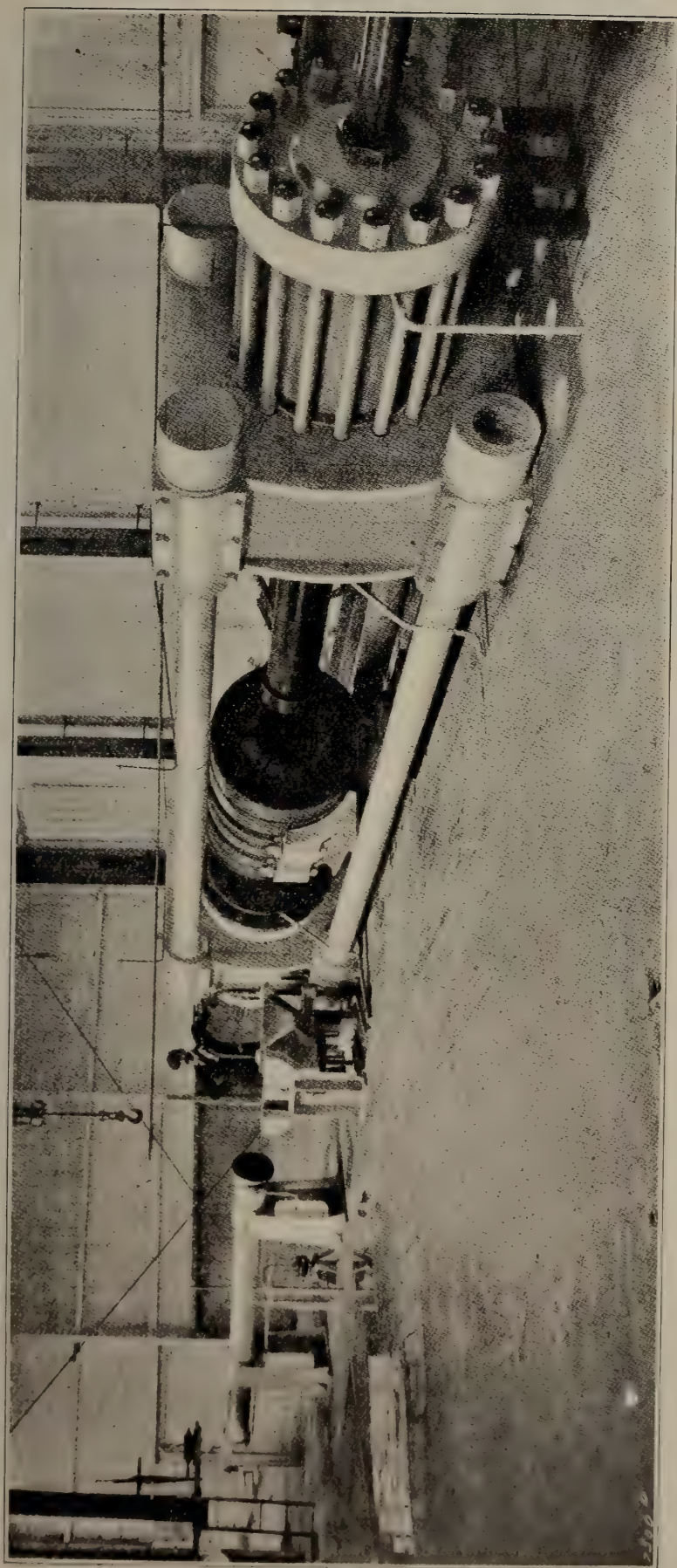


FIG. 4.—PRESSING AND MOLDING GUN COTTON IN SOLID BLOCKS AT HIGH DENSITY.

rams are now withdrawn, and the mold is again swiveled so as to be in the same position as when the charge was being inserted—that is, in line with the side ram. The latter then comes into play again and pushes the charge out of the mold onto the cradle provided for the purpose, and shown in fig 4. In fig. 3 is shown, slung in the hydraulic crane, a block of gun cotton, which will form the charge for a White-head torpedo.

We must now make reference to an important feature in the press, which contributes very largely to the safety of the process. In pressing the gun cotton in a cylinder or mold there is a chance that a portion of the material may be trapped between the ram head and the side of the mold. Being subject to great pressure, it might become dry, and in such a case the heat from friction might lead to an explosion, which would doubtless cause great damage and possibly loss of life. To meet this danger the ram head is formed as in figs. 11 and 12, which are a sectional view and an outside elevation. There is a spiral groove, having perforations at the bottom. Water at pressure passes into the chamber formed in the head, as shown in fig. 11, and is forced out into the groove. Water also passes through holes in the sides of the end disk or face of the ram, as shown in fig. 12, and there are other apertures through which water is forced out at the face itself, as shown in fig. 11. The high-pressure water in the helical groove tends to prevent particles of gun cotton from getting between the sides of the ram head and the walls of the mold or cylinders; or, if any should get past the outer disk, it is retained in the groove, where it is well drenched with water, and thus rendered harmless. The water also acts as a lubricant for the ram. The holes in the face likewise keep the gun cotton wetted and prevent pieces sticking to the face plate.

There are, it will be seen, several advantages in thus forming shell charges or torpedo charges in one block on this process. In the first place, owing to the expulsion of air in the process of formation, as already described, the hydraulic pressure in forming the charge can be considerably less than in the old method, although blocks of so much greater size are made. No space is wasted as with built-up charges, the saving in this respect affording about 15 per cent more gun cotton than under the old method. A strong metallic case is not needed, as the charge will keep together of itself. An envelope of thin waterproof material is sufficient for the purpose. The uniform density of charges secured by the process gives more complete detonation of the entire mass, and the presence of a uniform amount of moisture adds to this quality. It is also found that the process of manufacture is so much under control that theoretical density may be obtained, and any required amount of moisture can be left in the charge over the theoretical maximum corresponding to the density. Another

advantage is that when a number of similar charges with conoidal or other shaped ends have to be made, they can be produced exactly in duplicate, without the necessity of turning the charge in the lathe. The advantages generally in this respect are very great.

The company have conducted numerous experiments in firing gun cotton built up in disks as a bursting charge for shells, and in other situations. As no zinc case is necessary to contain the charge, it can be placed naked direct into the cavity of the shell. This enables quite 20 per cent more gun cotton to be got into the same sized cavity. The block also is so shaped that it forms a perfect fit to the shell cavity, and when the fuse is screwed home it is so tightly secured that neither the shock of discharge nor the centrifugal action set up by the shell in flight can remove it or disturb its position. A point of advantage in regard to torpedoes occurs in the greater stability that is secured by the new method. If, in these weapons, anything happens to alter the determined center of gravity, the accuracy of flight and aim can not be relied upon. It is stated that the method of charging war heads by means of built-up charges frequently destroys their efficiency. Although a charge may be accurately balanced at the time of loading, the play that takes place between the large number of disks, or segments, often shifts the center of gravity. This, of course, does not occur with a solid charge, supposing it to be well shaped and accurately fitted. In the case of torpedoes it has been found that even more than 20 per cent of additional gun cotton can be got into the war head when a solid charge is used, as compared to the built-up charge. The gun cotton used for these charges is made at the company's works at Stowmarket, and is prepared with the usual materials in the ordinary way. It may be stated that should it be desirable to adopt the new form of solid charges the old stock need not be thrown away, as it can be worked up and pressed again by the new process. The same system may naturally be used for making large solid blocks of gun cotton for submarine mines and other purposes for which this explosive is employed in naval and military operations.

The press seen in operation at Stowmarket will take blocks of 30 inches in diameter up to 3 feet 6 inches long. It is stated also that in the cost of manufacture by the new process there is a saving of quite 25 per cent. Gun cotton has been compressed in this way to as high a specific gravity as 1.523, the hitherto technical limit being 1.4.

Fig. 5.

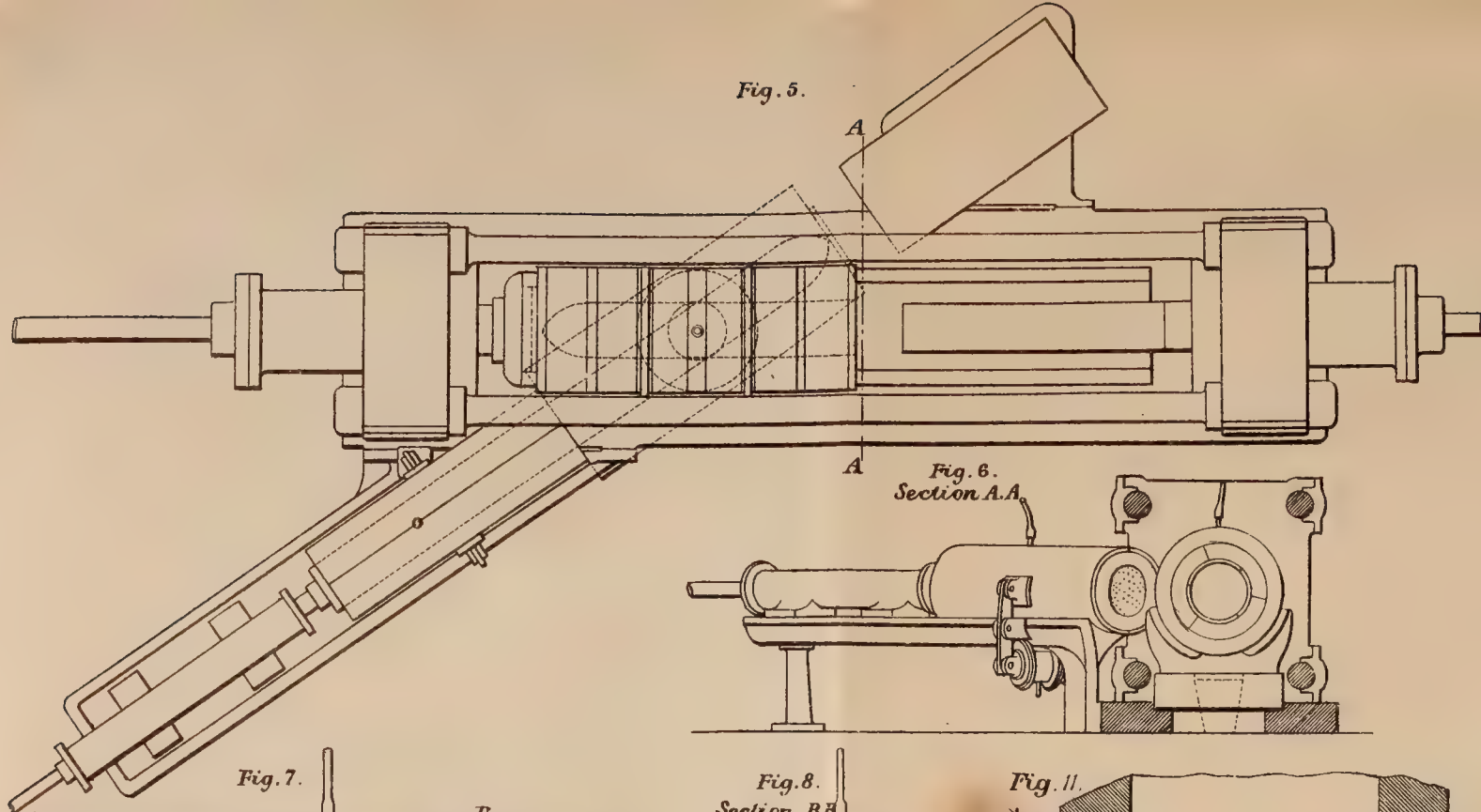


Fig. 6.
Section A.A.

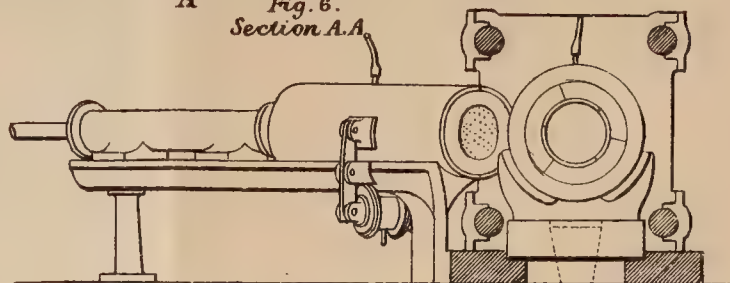


Fig. 7.

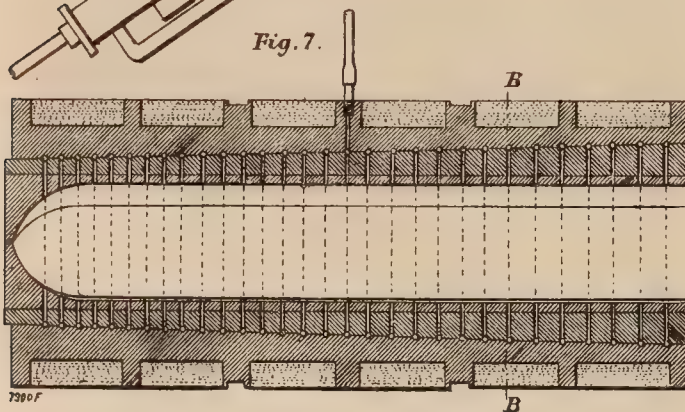


Fig. 8.
Section B.B.

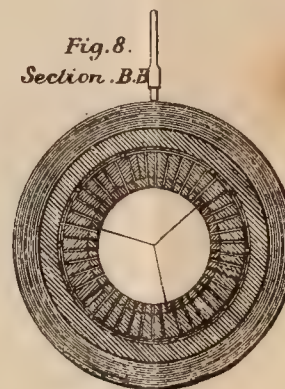


Fig. 11.

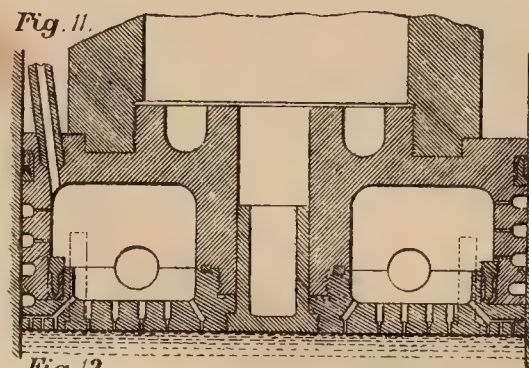


Fig. 12.

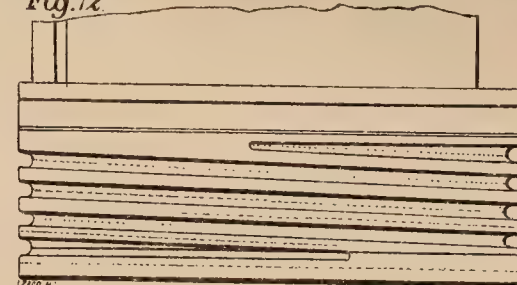


Fig. 9.

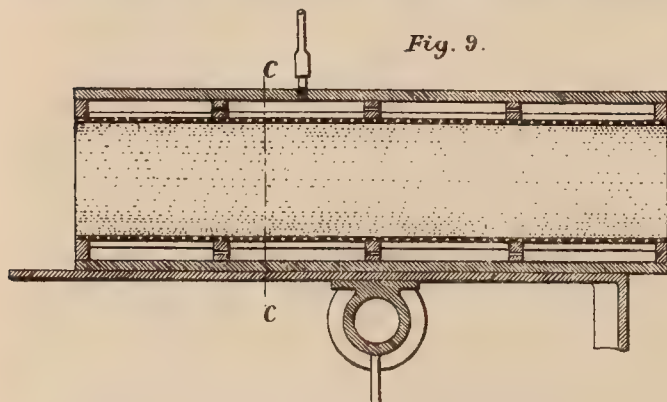
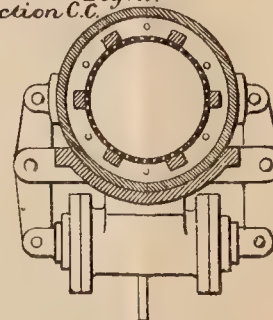


Fig. 10.
Section C.C.



MANUFACTURE OF GUNCOTTON CHARGES—DETAILS OF PRESSES.

SECTION VI.

PROJECTILES.

Recent experiments with capped armor-piercing projectiles again demonstrate the value of the cap as an aid to the penetration of armor plates. These experiments are given in full in the chapter on armor. Two general methods of securing the cap have been used, in one the cap being held in place by projections on the point of the shell, and in the other by being forced into a groove cut into the shell. The latter method is that used in securing the Johnson cap, used in the experiments by Vickers, Sons & Maxim, and is illustrated in the projectile shown in the account of tests of Beardsmore plates. This method of securing the cap has the advantage of permitting the utilization of shell already on hand.

The value of lyddite shell upon armor is shown in the recent *Belleisle* experiment, and is recorded under that head in the chapter on armor.

A shell of a new type has been introduced into the German army and is stated to be receiving the attention of the British war office. By the introduction of a cartridge composed of amorphous phosphorus into the ordinary charge of smokeless powder a thick, white smoke is emitted when the shell bursts, thus showing the gunners, even at the greatest distance, how close the projectile has gone to the enemy's position. By increasing the proportion of this chemical, an operation which does not lessen the bursting effect, it is possible to deposit in front of the enemy's position a thick bank of white smoke which will obliterate his view of the field. Experiments with this shell are said to have proven highly satisfactory.

It is further stated that the Germans, with a view to the more efficient control of the fire of the various guns on board ship, are experimenting with smoke-producing compound for projectiles of the main and secondary battery.

Each caliber of the larger guns is to have its shell contain, in addition to the bursting charge, a smoke-producing compound which will produce a different color for each general type of gun.

PRESS FOR COPPER BANDING SHELLS.

[From The Engineer.]

The following are the essential features of a properly fixed band: (1) It must be pressed so firmly on the shell that every portion of it is home

in the groove, completely filling the undercuts, and so that the serrated projecting vees on the shell, arranged to prevent the ring rotating without the projectile, are firmly embedded in the copper. (2) All the portions of the band should be equally compressed, so as to possess the same degree of density. (3) While the band must be pressed on with sufficient power to fulfill condition (1), the shell itself must not be upset enough to prevent the easy insertion of the screw gauge in the fuse seat in the base of the shell.

The usual methods of forcing the bands into the grooves are either the use of a pair of semicircular dies brought together by a hydraulic ram, or forcing the shell through a conical die. The former method has the disadvantage of not compressing the band equally throughout its circumference, while the latter method has a tendency to cause the copper to flow toward the rear of the shell. Another objection to the use of the conical die is that the least variation in the thickness of the rough copper band has a corresponding effect on the degree of tightness with which the compressed band grips the shell.

In the press under notice the makers claim that the above disadvantages are conspicuous by their absence, and as this type of press is used at the shell factories, Woolwich, it would appear that the process was an advance in the right direction.

The system employed is that commonly known as "West's patent system," in which a quantity of rams are arranged circumferentially on a bedplate and capable of traveling toward a common center, and the principle of the shell-banding presses will be readily understood from the photographs and drawings shown. Shells from 4.7 inches to 12 inches in caliber can be banded in this press. Fig. 3 is a plan, and fig. 2 shows a half section taken through the center of one of the cylinders. The following is a brief description of this size of press: A is a strong cast-iron bedplate, circular in form, supporting a weldless rolled nickel-steel ring, B, 9 inches deep and 8 inches broad; to the inner circumference of this ring are fixed eight steel cylinders, C, 15 inches in diameter, with S. M. steel rams, D, guided by means of a smaller ring, E, and carrying on their ends removable die blocks, curved to suit the periphery of the copper band. Pressure is conveyed to the cylinder by means of radial pipes, H, communicating with a common distributing chamber, K. The rams are all single acting and their return is effected by the springs shown, one of which is placed under each ram.

Pressure is supplied by means of a two-throw belt-driven pump, working up to 4,500 pounds per square inch when pressing the largest sized bands, but in some cases the makers supply a small intensifier instead of the pump, so as to utilize existing hydraulic-pressure mains. The weight of the press in question is 12 tons. The copper rings are, of course, turned accurately to size after they are pressed on.

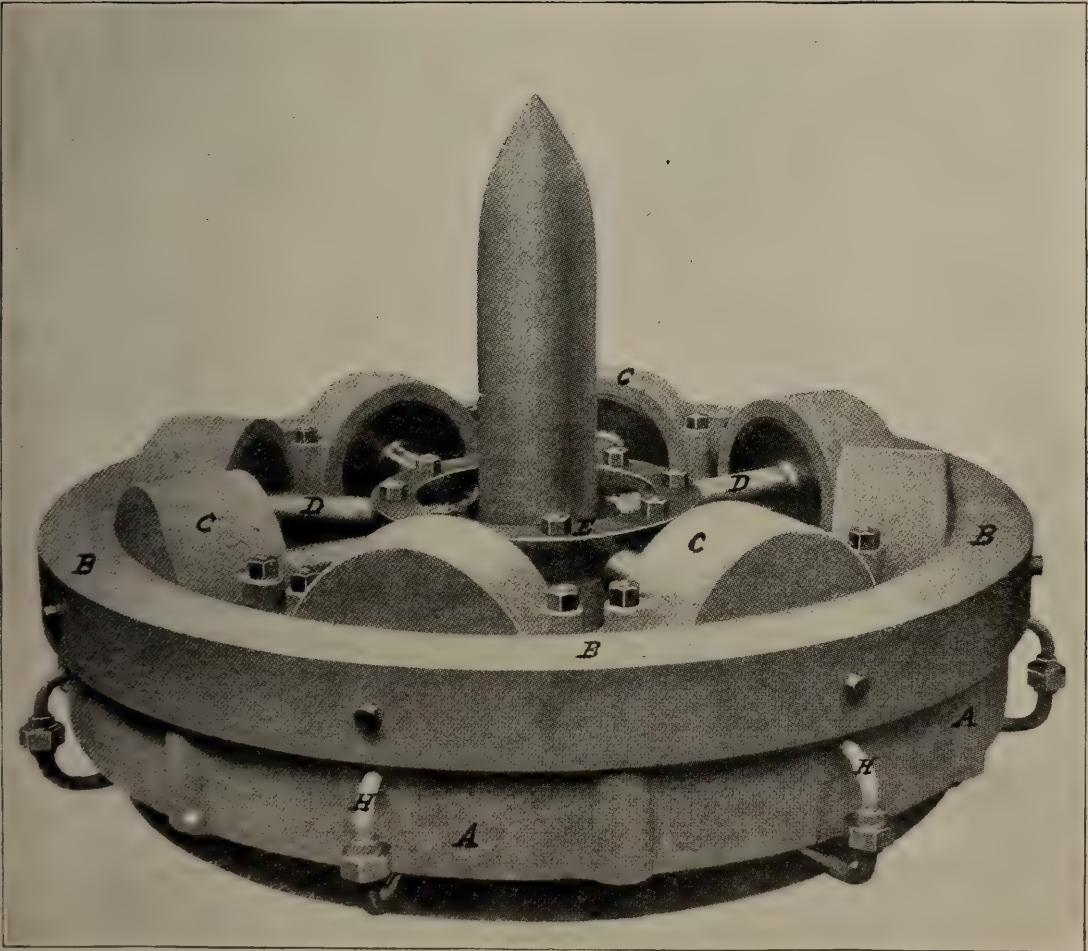


FIG. 1.—SHELL BANDING MACHINE.

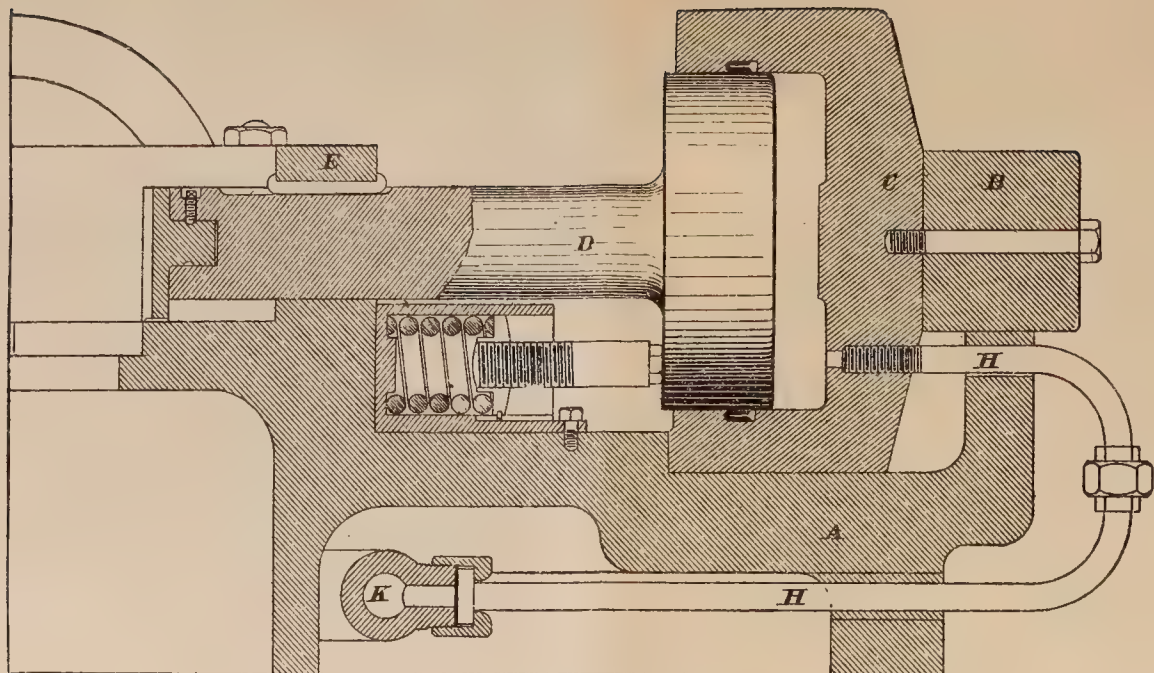


FIG. 2—SECTION OF PRESS.

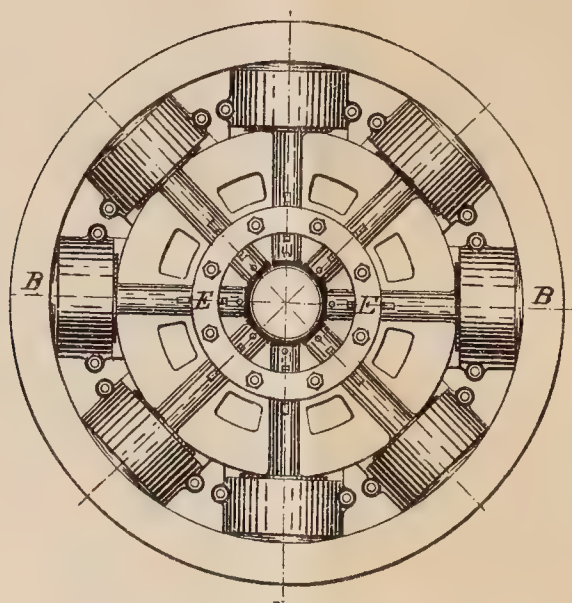


FIG. 3—PLAN OF PRESS.

KRUPP SAFETY DETONATING FUSE.

This invention relates to projectiles for ordnance, such as shells, and is designed to enable this class of projectile to be transferred from place to place, handled, and fired with complete immunity from danger.

The ordinary shell, the bursting charge of which, as is well known, consists of some high-power explosive which is only detonated with difficulty, such as picric acid, gun cotton, dynamite, or the like, requires (in order to insure the bursting charge being detonated with certainty) a violent agitation to be imparted by means of a special igniting charge. For this purpose mercuric fulminate is most generally used, but as this compound is itself very easily detonated it gives rise to the dangerous possibility of its becoming ignited by the shock caused by the discharge of the projectile and so producing the bursting of the shell in the barrel of the gun.

For this reason shells containing an igniting charge of mercuric fulminate have to be carried about and handled with extreme caution, and even with the most careful handling accidents can not be avoided.

On this account various attempts have already been made to provide shells with other kinds of igniting charges in place of mercuric fulminate; thus, for example, it has been proposed to employ as a substitute for the mercuric fulminate a charge of rapidly burning gunpowder inclosed in a thick but brittle tube of cast steel or cast iron surrounded by the bursting charge.

Experiments therewith show, however, that by means of such an igniting charge merely a simple explosion is caused which only breaks the projectile into a small number of pieces, but does not detonate the bursting charge and therefore does not fulfill the conditions required of such shells.

According to the present invention, an igniting charge of gunpowder, or a mixture of materials which produce in combination a similar effect to gunpowder, is made to detonate the bursting charge with certainty by forming the igniting charge of separate portions inclosed in separate chambers placed one behind another.

In the accompanying drawings figure 1 shows in longitudinal section one example of a shell fitted according to this invention with an igniting charge in two parts. Figure 2 is a second example of the invention in the form of a shell shown in longitudinal section with an igniting charge in three parts. Figure 3 shows a shell corresponding to that shown at figure 2, but with a slight modification of the arrangement of the igniting chambers.

In all three figures similar parts are designated by the same reference letters.

Referring to figure 1 of the drawings the body A of the projectile and the fuse B, which is assumed to be a combination fuse, are of ordinary construction. Within the body A is placed the bursting charge

C, consisting of picric acid or the like, and the hollow chamber containing the charge is closed by the screw plug D. This latter contains a chamber filled with the igniting charge P^1 , which chamber communicates with the interior of the projectile by an ignition port b , and on the side next the fuse B is closed by a screw F, provided with an ignition port a . A second and larger igniting charge P^2 is inclosed in a thin, brass tube G, the lid of which, next the igniting charge P^1 , is provided with a fire hole, said tube being inclosed in a central recess in the bursting charge C.

When the shot is fired, the combination fuse B, whether it be used as a time or percussion fuse, explodes the igniting charge P^1 , either at the proper time for which the fuse is set or upon the impact of the projectile, as the case may be. As this igniting charge P^1 is tightly inclosed in the screw plug D, it explodes with great violence, and thereby causes the immediate explosion of the second igniting charge P^2 . The explosion of this latter, being itself produced by a violent explosion, takes place with increased violence and thereby imparts a sufficient exciting effect to the bursting charge to insure its ready detonation.

The shell illustrated in figure 2, with the exception of its size, and the fuse B, which is assumed to be a percussion fuse, differs only from that illustrated at figure 1 in being provided with three igniting charges $P^1 P^2 P^3$ instead of two. The charges P^1 and P^2 are inclosed in chambers formed by screwing two tubular cases E^1 and E^2 into a cylindrical hollow in the screw plug D. The third igniting charge P^3 is contained in a capsule H, screwed onto the pin d of the screw plug D and projecting into a central hollow in the bursting charge C. The igniting charge P^1 communicates with the fire chamber of the fuse by the ignition port a , the charge P^1 with the charge P^2 by the ignition port b , and the charge P^2 with the charge P^3 by the port c .

The shell illustrated at figure 3 only differs from that illustrated at figure 2 in that the capsule E^2 is prolonged downward into a tube so as to reach down into the charge P^3 . As by this arrangement the two charges P^2 and P^3 are concentric with one another and with the bursting charge, the ignition port c (shown in figure 2) may be omitted.

The method of operation of the two last-described shells corresponds to that of the shell shown at figure 1.

When the projectile strikes, the fuse B first explodes the charge P^1 , and the charges P^2 and P^3 then explode in succession and finally cause the detonation of the bursting charge C.

In order to render the action of the igniting charges in all three examples of shell described certain, it is important that the first charge P^1 be tightly inclosed on all sides. For the last charge this is not absolutely necessary. For example, the last charge (the one inside

Fig. 2.

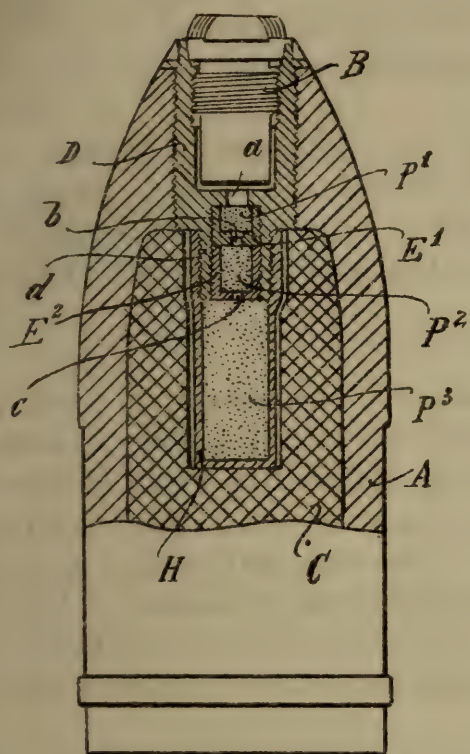


Fig. 3.

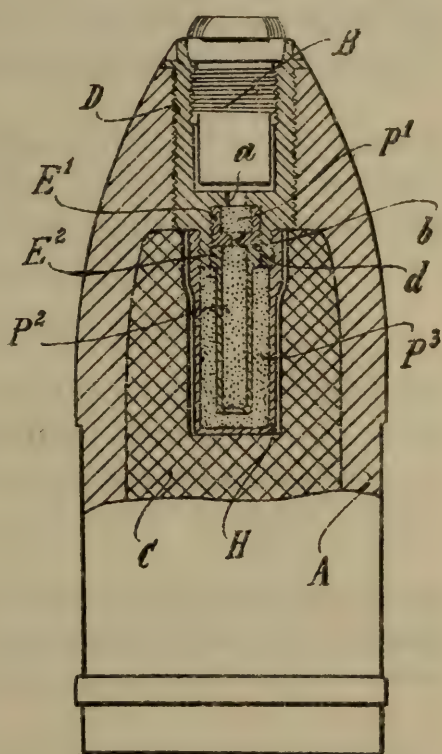
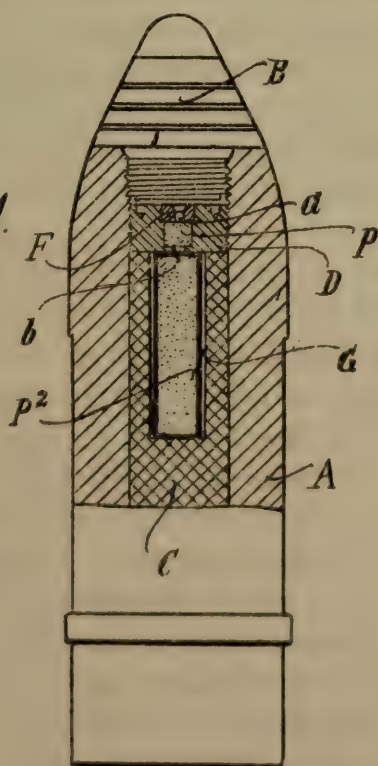


Fig. 1.



the bursting charge) may be inclosed in a paper case. The capsule H employed in the forms of shell shown in figures 2 and 3 is of no importance in the working of the igniting charge and is only for the purpose of attaching the igniting charge to the screw plug and keeping all the parts together as a whole and enabling them to be easily inserted in the projectile.

As the materials (gunpowder and the like) employed in the present case as igniting charge can not be exploded by concussion, as is the case with mercuric fulminate, it is obvious that shells as above described may be carried about, handled, and fired with perfect safety.

KRUPP SAFETY DEVICE FOR COMPOUND FUSES.

This device is arranged to lock both moving parts of the time and percussion arrangements of a combination fuse, allowing the projectile to be carried about with safety, yet allowing the safety device to be removed from both parts, by a single movement of the hand, when it is desired to put the fuse into action.

This end is attained by providing the compound fuse with two safety pins, connected by a crosspiece, one of said pins securing the priming bolt of the time fuse and the other the moving parts of the percussion fuse.

There is shown at figures 1 to 4 of the accompanying drawings a compound fuse of the usual general construction and fitted with the new safety device. Figure 1 is a section through the longitudinal axis of the fuse. Figure 2 is a cross section on the line II—II of figure 1, looking from above and showing the powder ring displaced. Figure 3 is a cross section on the line III—III of figure 1 looking from below. Figure 4 is a side elevation of the fuse. Figure 5 shows another example of the safety device.

The construction and mode of operation of the compound fuse, apart from the safety device, are of the ordinary kind, and will therefore be only so far described as concerns their connection with the safety device. The ignition of the prepared powder in the fixed powder ring P and the rotary powder ring M of the time fuse is started at the moment of firing by the priming bolt A, which by virtue of its inertia overcomes the pressure of the carrier spring B and strikes against the firing pin Q. Simultaneously with the moving of the priming bolt A the locking ring E of the percussion fuse moves backward and slides over the priming bolt C against the resistance of the carrier spring D. When the projectile strikes, the priming bolt C, which till now has been prevented from moving forward only by the spiral spring F, darts forward, together with the carrier spring D and the locking ring E, against the needle R, and directly effects the ignition of the bursting charge of the projectile.

The safety device consists of two safety pins G and H, and a cross

piece J to which the pins are riveted. The longitudinal axes of these three parts lie in one and the same plane. For the sake of brevity the construction formed by the pins and the cross piece will be hereinafter referred to as the "compound safety pin."

Pivoted to the crosspiece is a spring ring K, which, as will be more particularly described hereafter, serves to secure the compound safety pin in position when applied to the fuse, and also provides for the easy removal of the compound safety pin from the fuse.

Within the fuse itself are provided two passages to receive the pins G and H, the axes of these passages both lying in one plane, passing through the axis of the fuse and through the bridge of the rotary powder ring M, and both lying at right angles to the longitudinal axis of the fuse. The passage for the top pin G passes above the fuse body N into the screw cap L, through the priming bolt A, and terminates in the portion of the cap diametrically opposite the point of entrance. The passage for the bottom pin H starts in the bridge of the rotary powder ring M, passes through the adjacent part of the fuse body N and the locking ring E, and terminates in the portion of the fuse body diametrically opposite the point of entrance.

Screwed into the screw cap L is a screw O, the point of which penetrates into the body of the fuse and prevents the cap from revolving; the head of this screw serves as a fulcrum for the spring ring K of the compound safety pin.

The condition of the compound fuse while being carried about is shown in figs. 1 and 4. The pins G and H of the compound safety pin lie in their passages in the fuse, and the crosspiece J lies against the outside of the fuse. The spring ring K, which has a certain amount of lateral play (see particularly fig. 3), surrounds the screw cap L and grips underneath the head of the screw O. In this condition of the compound fuse it will readily be seen without further explanation that the priming bolt A, the locking ring E, and the powder ring M are all secured, and the path of the priming bolt C to the needle is blocked. The compound safety pin itself is also secured in position with regard to the fuse by the ring K.

To put the fuse in action, the ring K is laterally pressed together till free from the head of the screw O, and then turned over into the position shown in dotted lines in fig. 3. By grasping the ring the compound safety pin may now be withdrawn from the fuse. The fuse, after the proper setting of the powder ring has been effected, is now ready for the discharge.

The hole for the bottom pin H is preferably bored in the powder ring M when this latter is in the case-shot position, i. e., the position in which it starts the ignition of the bursting charge of the projectile, immediately in front of the muzzle of the gun. The advantage of this in the first place is, that the projectile, in cases where case-shot

Fig. 3.

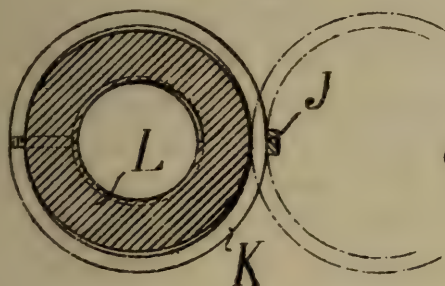


Fig. 5.

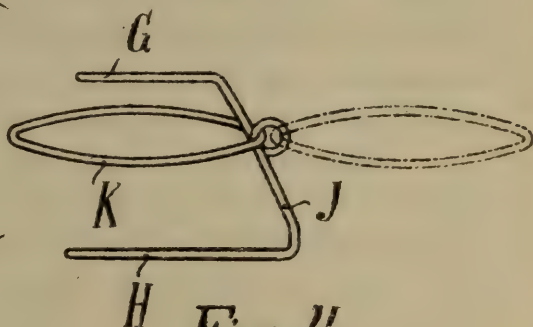


Fig. 1.

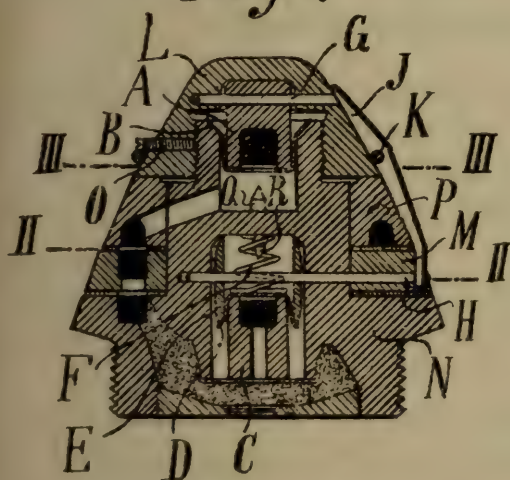


Fig. 4.

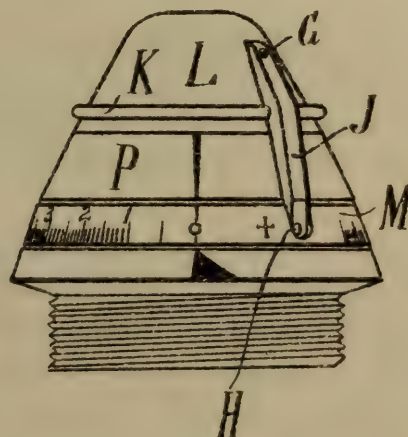
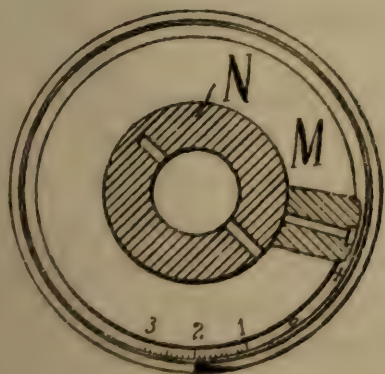


Fig. 2.



fire is indicated, and which demand instant readiness of fire, is immediately ready to be fired the moment the compound safety pin is withdrawn.

Secondly, this arrangement of the passage for the bottom pin, by reason of the necessary adjustment of the powder ring M for the long-range fire, causes the passages in the powder ring and the body of the fuse to become displaced with respect to each other (fig. 2). By this means the chamber in the fuse body containing the parts of the percussion fuse is closed externally, thereby preventing the entrance of earth or water into the interior of the fuse when the projectile strikes, which would render the action of the percussion fuse doubtful.

The pins G and H may obviously be made in some cases integral with the crosspiece J. An example of this kind is shown at fig. 5, according to which the pins and crosspiece are bent up out of wire. The spring ring K is in this case inserted in an eye bent in the wire.

KRUPP'S IMPROVEMENT IN CARTRIDGE CASES.

This improvement is designed to prevent the propelling gases from entering the space between the cartridge case and the cartridge chamber. This object is attained by making the driving bands, at least one of them, fit into an enlargement in the mouth of the cartridge case itself.

The cartridge A is formed with an enlargement so that a rim is formed projecting outwardly beyond the remaining outer surface of the case. The rim is of such a diameter that only the necessary play is left between it and the cartridge chamber D in the barrel of the gun, in order to enable the cartridge to be inserted. The driving band C of the projectile B is provided with a reduced portion *c* fitted into the enlargement *a* of the case by pressure. When the cartridge is put together the shoulder *c*¹ of the driving band limits the insertion of the projectile into the case, because it bears against the outer edge *a*¹ of the case.

When the gun is fired, the propelling gases, before the projectile begins to move, expand first the part of the case below the base of the projectile and then pursue their course between the interior wall of the case and the part of the projectile below the driving band C. The gases now expand this portion of the case, so that it first bears gas-tight, with its rounded edge *a*² against the sides of the cartridge chamber. When the projectile begins to move, the gases then bring the outer surface of the enlarged portion *a* of the case into contact with the barrel. This contact remains permanent, as numerous experiments have proved, throughout the remainder of the movement of the projectile, so that the entrance of the gases into the space between the case and the cartridge chamber is prevented. By this means all the injurious results of this entrance (fouling of the cartridge chamber

and the breech block, loss of gas, and consequent irregularities in the initial velocity of the projectile) are entirely avoided.

It is not absolutely necessary that the driving band C should have a shoulder c^1 . The driving band may equally well be shaped as shown in dotted lines in fig. 2. In such case, however, care must be taken, when putting the cartridge together, that the projectile is not forced in too far. If required, the shoulder a^1 may be dispensed with by making the driving band seat itself upon the shoulder formed at the base of the enlargement a . Under certain circumstances the driving band may be completely sunk into the enlargement a , which is correspondingly deepened for the purpose.

When the projectile is provided with several driving bands, they may all lie within the enlargement, or that one nearest the cartridge case only may be made to fit into the enlargement.

Fig. 1.

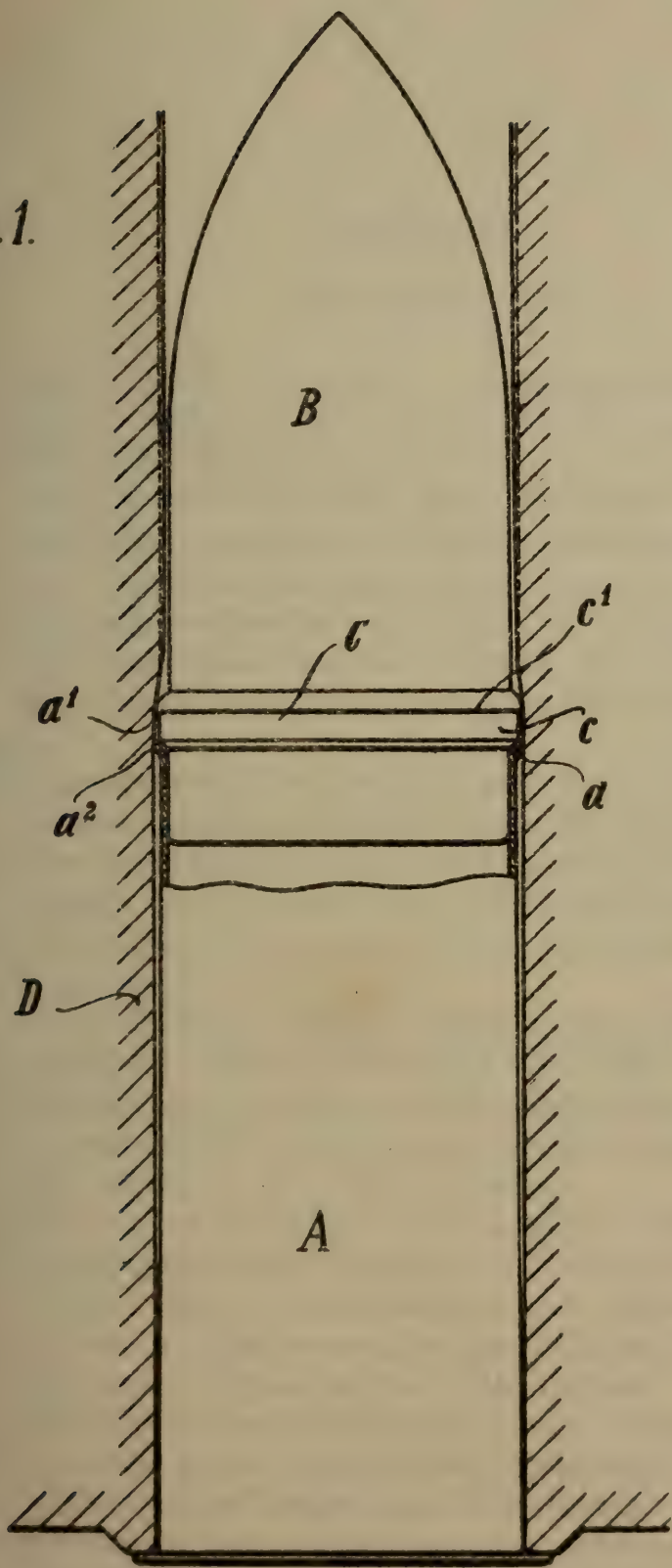
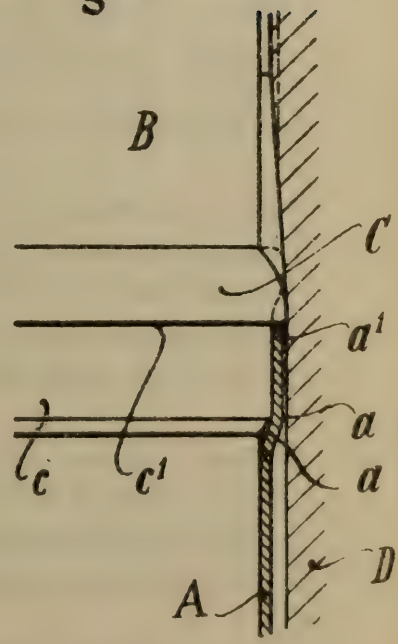


Fig. 2.



KRUPP IMPROVEMENT IN CARTRIDGE CASES.

SECTION VII.

TORPEDOES.

The exercise heads of torpedoes in the German navy are filled with earth or sand. This material is said to have the same weight and volume as the service charge of gun cotton.

In Austria the exercise heads have been filled with tallow. The head is made of thin material, and the torpedoes fired directly at ships under way. Upon striking, the head is collapsed and the shot registered by the tallow adhering to the ship's side at the point of impact.

There are indications that the German navy have made experiments with a device considerably enlarging the area of action of their torpedoes.

In these experiments the torpedoes were fitted with a device on the gyroscopic steering gear, which, by means of a small steering engine, would make the torpedo run in a spiral or zigzag course after having made a straight run of 1,000 meters, the torpedo in the meantime having failed to explode by reason of not having hit the target at which it was originally fired.

This device consists of fitting a template about the size of a watch on the gyroscope. This template is an exact circle for three-quarters of the circumference, the other fourth being cut eccentrically, so that in the last quadrant this portion causes the gyroscopic engine to steer the torpedo spirally or in a zigzag course.

The idea involved is as follows: In an action between fleets or in a torpedo attack against fleets, torpedoes will be fired straight at a range of 1,000 meters; then if a torpedo shall have missed striking, it will turn and pursue a zigzag course, the general direction of which is at right angles to the original course of the torpedo. The torpedo will thus threaten the entire column of the enemy's vessels. Reports as to the utility of this device are conflicting in character.

In the Schwartzkopff torpedo and in the German modification of the same the bronze air flasks are permanently sealed and the heads permanently soldered therein. Bronze torpedoes are considered in Germany as being superior to steel, as there is no rust, no oil or vaseline necessary, and no necessity of an inspection of the interior of the air flasks. The slight difference in the first cost of the bronze machine is offset by the less cost of maintenance.

Practice with these torpedoes in the German navy has made them perfectly reliable weapons. The color of the bronze torpedo renders it more visible in the water, and reduces the danger of loss in practice runs.

The torpedo in the German navy is considered as a positive and reliable element. There are no indications of its being abandoned in the under-water tube on board ship.

SOME RUNS OF THE SCHWARTZKOPFF TORPEDO FITTED WITH THE KASELOWSKI ATTACHMENT.

These runs were made in August last at the experimental station of the Berliner Action Gesellschaft at Kiel.

The target was a float 80 feet long, 5 feet wide, and 3 feet draft. In the center, surmounted by a flat disk and about 10 feet apart, were two long poles. Observers are stationed on the target to note the action of the torpedo at that point, and also to note the action at the end of the run. The target was anchored so as to present a broadside to the firing station.

Experiments were made with two torpedoes, 3824 and 3825, two runs being made with each on two successive days, except that on the second day three runs were made with 3825.

The torpedoes were fired with compressed air, and discharged from the wharf. The runs were rapidly made. After the runs each torpedo was hoisted to a convenient height to admit of recharging from the accumulators on the wharf, the Kaselowski attachment being readjusted by simply pressing down on the disk on the head of the rod.

The remarkable facility and ease with which the same torpedo was repeatedly discharged was striking. There was no need of cleaning the bronze torpedo, it was not even necessary to wipe it off, but was ready for another run as soon as it could have its air flask recharged. The Kaselowski attachment was in that period reset by simply pushing down the rod.

The results of nine runs of these two torpedoes are given on the accompanying plates—copies of the blanks furnished by the firm and recorded in the presence of officers and men from the U. S. S. *Hartford*.

The accuracy of the runs, and the exact working of the Kaselowski attachment, are illustrated in this record.

The record of the three shots Nos. 397, 398, and 399 is worthy of note. In these the torpedo was fired as if toward the target anchored broadside to the pier at 1,000 meters (3,280 feet). It ran straight out for a distance of about 75 yards and then, turning through 45 degrees, went straight along a line of 7 buoys at a distance of 25 yards parallel thereto.

Experiment No. 400 with this same torpedo, 3824, was made imme-

Current No. of Shot.	No. of the Torpedo.	Place & Date of Experiment	Wind, Sea & Current	Torpedo.											Remarks.	Vertical Course of Torpedo.	Horizontal Course of Torpedo.
				Temperature of Air & Water.	Pressure in Flask.	Depth of Float.	Position of Regulator.	No. of Teeth.	Change in the vertical Rudder.	Rudder Stop.	Distance.	Time of Run.	Speed.	Remaining Air Pressure.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
397	3824.	Kiel, August 1. 1901	Tide →	W. 21 A 21	100	3.0	9	16	Autoregulator	50 -20 Teeth	Port.	Angle	24				
398				W. 21 A	.	.	.	.	.	.	.	.	.	24			
399		August 6. 1901.	↑ Wind	W. 21 A 15	100	3.0	9	16	.	50 -20	.	.	.	24			
400				W. . A	.	.	.	18	.	.	1000	68.12	28.5	17			

Current No. of Shot.	No. of the Torpedo.	Place & Date of Experiment	Wind, Sea & Current.	Torpedo.											Remarks.	Vertical Course of Torpedo.	Horizontal Course of Torpedo.
				Temperature of Air & Water.	Flask Pressure.	Depth.	Position of Regulator.	No. of Teeth	Change in the vertical Rudder.	Rudder Stop.	Range	Time of Run.	Speed.	Remaining Air Pressure.			
				Reg. Cel.	Atm.	M.	M.M.			Teeth	M.		Knots	Atm.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
366	3825.	Riel, August 1. 1901.	Tide →	W. 21. A. 21	100	2.7	8	18	Autoregulator. 60 -20 Teeth	60	1000	66.90	29.1	16			
367	.	.	.	W. . . A. . .	.	.	.	.	.	.	.	66.48	29.2	15			
373	.	August, 6. 1901	No Tide.	W. 21 A. 15	100	2.7	8	18	80 -20 5.	80	1000	67.20	29.0	15			
374	.	.	.	W. . . A. . .	.	.	.	.	.	.	.	67.13	29.0	15			
375	.	.	.	W. . . A. . .	.	.	.	.	Port 10°	.	.	67.00	29.0	14	With Autoregulator.		

diately after it had been fired to diverge 45 degrees in 399. The adjustment was exceedingly simple to set it for direct run, and the record shows the accuracy of that run.

The perfect confidence of the engineer in charge of the station as to the course of the torpedo was exemplified by the fact that a fisherman laid out nets near the line of fire and run No. 399 was made to run around that boat, leaving his boat on the port side of the course of the torpedo.

The confidence in the accuracy of the run of this torpedo is obtained by the action of the Kaselowski attachment. The Kaselowski attachment is a modification of the Obry steering device. The impulse is given the gyroscope by two jets of air, on opposite sides of the wheel, acting on the serrated surfaces of the wheel, and thus producing rotation. The air acts on the wheel for a short interval and is then automatically shut off. Being actuated by constantly the same force on periphery of the fly wheel, there is no sudden shock on the mechanism, as in the Obry attachment, with its strong spring. The teeth of the gearing of the apparatus are thus preserved intact, while it has frequently occurred that in the Obry attachment the teeth of gearing are torn off by the strong blow of the spring in the Obry gear, which must be taken to the torpedo depot for repair, while the torpedoes with Kaselowski attachment have been fired several hundred times without interruption with the same attachment, this being especially the case with these two torpedoes, Nos. 3824 and 3825.

After the torpedo has run its course, the Kaselowski attachment is set by simply removing a screw cap and pressing down a lever.

In the late models of the torpedo the Kaselowski gear is connected with the starting lever, so that the torpedo upon discharge sets the device for the next run.

SINKING DEVICE FOR TORPEDOES FITTED WITH THE OBRY GEAR.

This invention has for its object to provide torpedoes having Obry's gyroscope steering gear with a device which stops and sinks the torpedo if such gear fails to operate.

Fig. 1 is a cross section through the torpedo chamber showing a side view of the device. Fig. 2 is a partial plan thereof in the direction of the arrow 34. Fig. 3 a cross section as seen from the right at line AB fig. 1. Fig. 4 is a longitudinal section at line CD, fig. 1. The screws 35, 36, shown in this figure, are used for fixing the device shown in fig. 1 to the shell; these screws, 35, 36, pass through the holes 38, 39, in the frame shown in fig. 1; on the other hand, parts are represented in fig. 4 which, for the sake of clearness, are left out in fig. 1. Fig. 5 is a partial plan of a few parts shown in fig. 4. Fig. 6 is a part shown in fig. 4 uncovered.

The device is constructed as follows:

Upon a suitable support *a*, which is secured to the shell by means of the screws 35, 36 passing through the holes 38, 39 (figs. 1 and 2), is carried a tube 3, in which is guided a cylindrical or prismatic bolt 4. One end of this bolt carries at a right angle thereto a bed 2, while the other end, which is flat and rounded off, glides upon the periphery of a sector 6 (figs. 1 and 2), adapted to oscillate on the bolt 9, and the periphery of which has in the middle a slight depression 7 (fig. 2).

The bolt 4, guided in the bearing 3, is pressed against the periphery of the sector 6 by a spring 5 (in fig. 2 shown broken off), one end of which is secured to the stud 9 and the other to a stud 8, secured to the bolt 4 and guided in a slot formed in the bearing 3, so that when the sector 6 is caused to oscillate the bolt 3 always engages in the sector depression 7 when the sector 6 passes its position of rest, while during the rest of the amplitude of the sector 6 it is pressed down upon the full part of the periphery thereof.

The sector 6 (see figs. 1 and 2 and particularly fig. 4) is connected with the steering rod *m*, actuated from the gyroscope motor by the draw rod 10 and the double-armed lever 11, and is thus set in oscillation by the alternate movement of the gyroscope.

In the bed 2 of the outer end of the bolt 4, a T-shaped slide 1 is employed (figs. 1, 2, and 3), the exposed edge 12 of which is formed with teeth which, when the bolt 4 has moved forward, i. e., when it bears against the full part of the said sector periphery 6, gears with a pinion 13 rotated at a uniform speed by the well-known counter of the air-admission valve or direct through the torpedo machine.

The slide 1, the downward motion of which is limited by the abutment screw 14, is drawn downward into the position shown in full lines by the spring 15, one end of which is attached to the stud 16, secured to the frame *a*, and the other end to the stud 17, on the slide 1. This slide moves only in the direction opposite to the pull of the string 15, when it is engaged by the pinion 13, which rotates always in the said direction. The slide 1 has a slot 18, in which engages the crank pin 19 of a cock lever 20, the cock 21 of which is inserted into an air pipe 22, branching from the main air pipe.

The plug of the air cock 21 in the usual manner is preferably made with double passages so as to balance the pressure of the air on the plug.

The slot 18 is of such a width that the slide 1 can move sufficiently laterally to bring the rack 12 in and out of gear with the pinion 13 without disturbing the crank pin 19.

The length of the slot 18 depends also on certain conditions of construction which will be more particularly referred to hereinafter in describing the working of the apparatus.

The air pipe 22, cut off by the cock 21, leads to the bottom of a closed cylinder 23, figs. 1 and 4, containing a piston 24, which is con-

nected with the air lever n by the rod 25, articulated thereto, which, when launching the torpedo, moves from the position shown in dotted lines into that shown in full lines.

This connection is such that when the air lever n is in the position shown in full lines, fig. 4, i. e., the torpedo is at full speed, the piston 24 will have arrived at the end of its instroke and at the end of its outstroke when the air lever n is in the position shown in dotted lines, fig. 4, the air pressure having acted upon the back of the piston, i. e., when the tap 21 has been opened.

The air lever may conveniently act on the sinking valve by the device hereinafter described.

The link 40, already existing and connecting the air lever n with the main air valve, is furnished with a laterally moving arm 30, figs. 4 and 5, on its end furnished with the horizontal stud 26.

This stud engages a pin 27, the head of which rests on the eye 28, fig. 6, suitably fixed, and the lower end of which passes through the eye 31, secured to the stem 29 of the sinking valve. (Owing to the head of the pin 27 and the eye 28 being covered in fig. 4 by the elements n and 25 they are shown separately in fig. 6.)

If the air lever n is turned off, the link 40 is pressed downward and the arm 30 drawn a little to the left (see dotted position), whereby the pin 27 will slightly swing around the suspension eye 28 to the left and thereby open the valve 32.

The apparatus works as follows:

As is well known, a steering gear operated by a properly working gyroscope will always oscillate regularly as long as it remains not perfectly in the launching plane of the torpedo, which oscillations, by the previously described connection between the steering rod m and the sector 6, are transmitted to the latter, the oscillation of which will also remain regular as long as the gyroscope works correctly and unless the steering gear remains perfectly in the launching plane and the torpedo therefore does not deviate from its launching direction.

Owing to this regular oscillation of the sector 6, the bolt 4, guided in the bearing 3, will be pressed forward during the action of the sector 6, and by the spring 5 caused to slide back the moment the sector 6 passes its position of rest.

The rack 12, on the slide 1, will thus always be in gear with the pinion 13 (which rotates always in the same direction and at the same speed), when the bolt 4 takes up its forward position and will come out of gear with the pinion 13, when the end of the bolt 4 enters the depression 7 in the periphery of the sector 6, which always takes place when the latter passes its position of rest.

The slide 1, as already explained, being drawn by a suitably arranged spring 15 in a direction opposite to the movement imparted thereto by the pinion 13, will fly back in the direction opposite to its

previous movement the moment its rack 12 comes out of gear with the pinion 13.

It will thus be seen that the slide 1 will be pressed upward in the direction of the arrow 33 (see dotted position in fig. 1) in the intervals between two successive transits of the sector 6 through its position of rest and be pulled back the moment the sector 6 passes its position of rest. The length of the slot 18 in the slide 1 is greater than the greatest possible travel of the slide 1 when the gyroscope operates regularly so that as long as the said intervals are not of greater duration than those that are possible when the gyroscope is in regular operation, the end of the slot 18 will never reach the crank pin 19.

But should the gyroscope fail to work and the steering gear remain permanently in any of its lateral positions which would endanger the torpedo returning to its own line, the slide 1 would also remain permanently in gear with its pinion 13 and be moved so far forward that the crank pin 19 would contract with the end of the slot 18 and thereby engage the slide 1 to open the air cock 21.

When opening the air cock 21 the air pressure enters the back end of the cylinder 23, drives the piston 24 forward, sets the air lever *n* into the cut-off position, thereby cutting off the air supply from the motor and at the same time, as previously described, opening the sinking valve 32, which causes the torpedo to be sunk.

SCHWARTZKOPFF SUBMERGED TORPEDO DISCHARGE TUBE.

The Berliner Maschinenbau Action Gesellschaft, formerly L. Schwartzkopff, have designed an improved type of underwater torpedo discharge tubes.

The tube is built in the ship as usual for underwater discharge, having an inner movable tube to carry the torpedo. This inner tube opens in the rear end to receive the torpedo. Two side cylinders, with pistons and piston rods, carry the inner tube with the torpedo out ready to fire. These piston rods are hollow and connect the space behind the pistons with the inner tube containing the torpedo. A special pipe conveys the air pressure that has carried out the inner tube to the other side of the piston. In the latter lead there are air-pressure reducers, so that the pressure on both sides of the pistons is equalized, the piston no longer moves, and the pressure then passes out through the hollow piston rods to force the torpedo out of the tube.

The sketch shows a broadside underwater tube to discharge torpedoes at right angles to the ship's course. The inner tube *a* (figs. 4 and 5) has guide grooves 1 of usual form. These serve to support the torpedo against the lateral pressure of water before the torpedo is clear of the ship.

The inner tube *a* moves in the outer tube *c* through a stuffing box

Fig. 5.

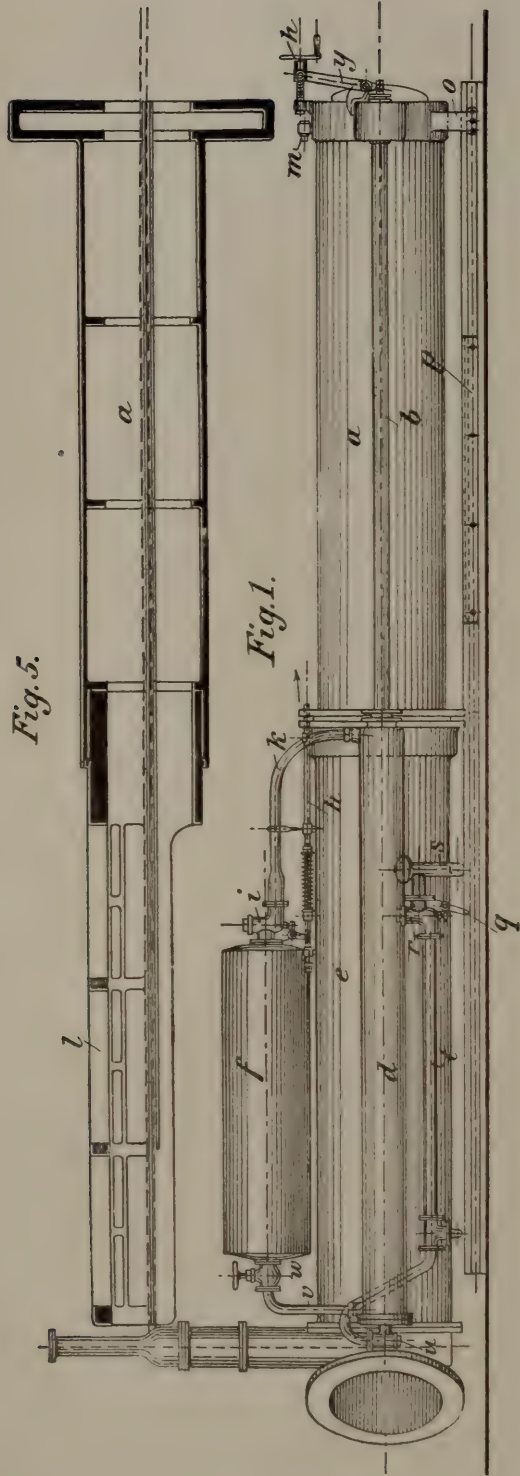


Fig. 1.

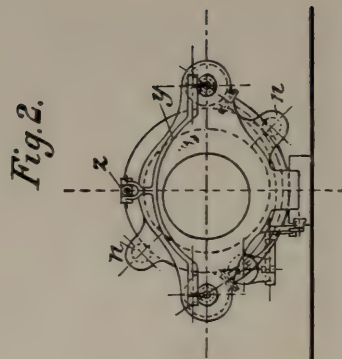


Fig. 3.

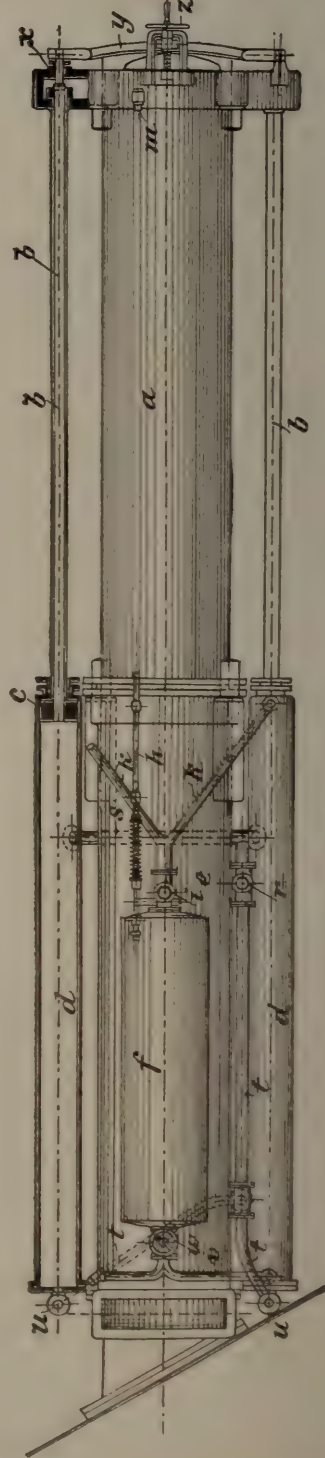
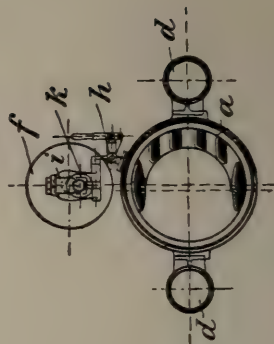


Fig. 4.



SCHWARTZKOPFF SUBMERGED TORPEDO DISCHARGE TUBE.

made water-tight in usual manner. Two cylinders d are placed alongside the outer tube e , the pistons c are in these and are connected by the hollow piston rods b with the inner tube a . This connection is such that the space outboard of the pistons is connected with the space at the inboard end of the inner tube a . The valve x , worked by means of the handwheel z and lever y , can break this connection.

An air tank f is placed above the tube e . This in connection through a cut-off i , with the rear end (inboard) of the cylinders e and by the pipe u and cut-off w with the front outboard ends of the cylinders d . The cut-off i , which may be a valve, slide, or cock, is opened by means of a so-called firing belt h , of desired construction, that moves as shown by the arrow in fig. 1. The cut-off i is closed automatically by coming in contact with the adjustable lug m on the tube a . (See figs. 1 and 3.) The cut-off w for the pipe v is worked by handwheel or lever. The pipe $s t$ connects the front and rear parts of the two cylinders d . In this pipe there is a cut off r , worked by the lever q . (Fig. 1.) This can be done automatically by the rail p , which carries the lug o and opens when it comes in contact with the lever q when the tube a is pushed out into the outer tube e . Reducing valves a reset in the mouth of this pipe with the cylinder d and the cut-off r is also fitted with a reducer.

The operation is as follows: Assume the apparatus in the position shown in the sketch, the inner tube a containing a torpedo. When the firing bolt h is moved as in the arrow, fig. 1, the cut-off i is opened and air pressure enters on the inboard side of the pistons c , forcing the inner tube a outboard into the outer tube e . This continues until the lug m comes in contact with the lever h and closes the cut-off i .

At the same time, or as may be adjusted, the rail p brings the offset o in contact with the lever q that brings the front and rear parts of cylinders d in connection. Air cushions are thus formed in the cylinders d , and the further movement of the inner tube a is stopped. This operation may be regulated as desired by opening and closing the respective valves, or it may be worked by hand and buffers be used to arrest the motion outboard of the inner tube a . The air-pressure reducers thus are adjusted to prevent any back action of the inner tube, that must be brought to rest in the outboard firing position. If the valve x is now opened the air pressure will return through the hollow piston rods and eject the torpedo from the tube. Before this is done the outboard disks that close the outboard side or port opening of the outer tube e is opened by means of the handwheel on top, as shown. In the photographs illustrated this handwheel, the gauges, etc., are working apparatus and are much larger in proportion to the other details of the working model.

After the torpedo is ejected, the air still remaining can be used to return the inner tube to the leading position. After the torpedo port

is closed, water that entered *e* can be also ejected through a suitable drainage pipe by means of the remaining air pressure. The cushioning arrangement, with its reducing valves, is found to supply all the needed power to return the inner tube and eject water through the drainage pipe.

Without going into details of the claims of the inventors the arrangement affords a tube for underwater discharge that is effective and which weighs much less than the underwater tubes usually adopted.

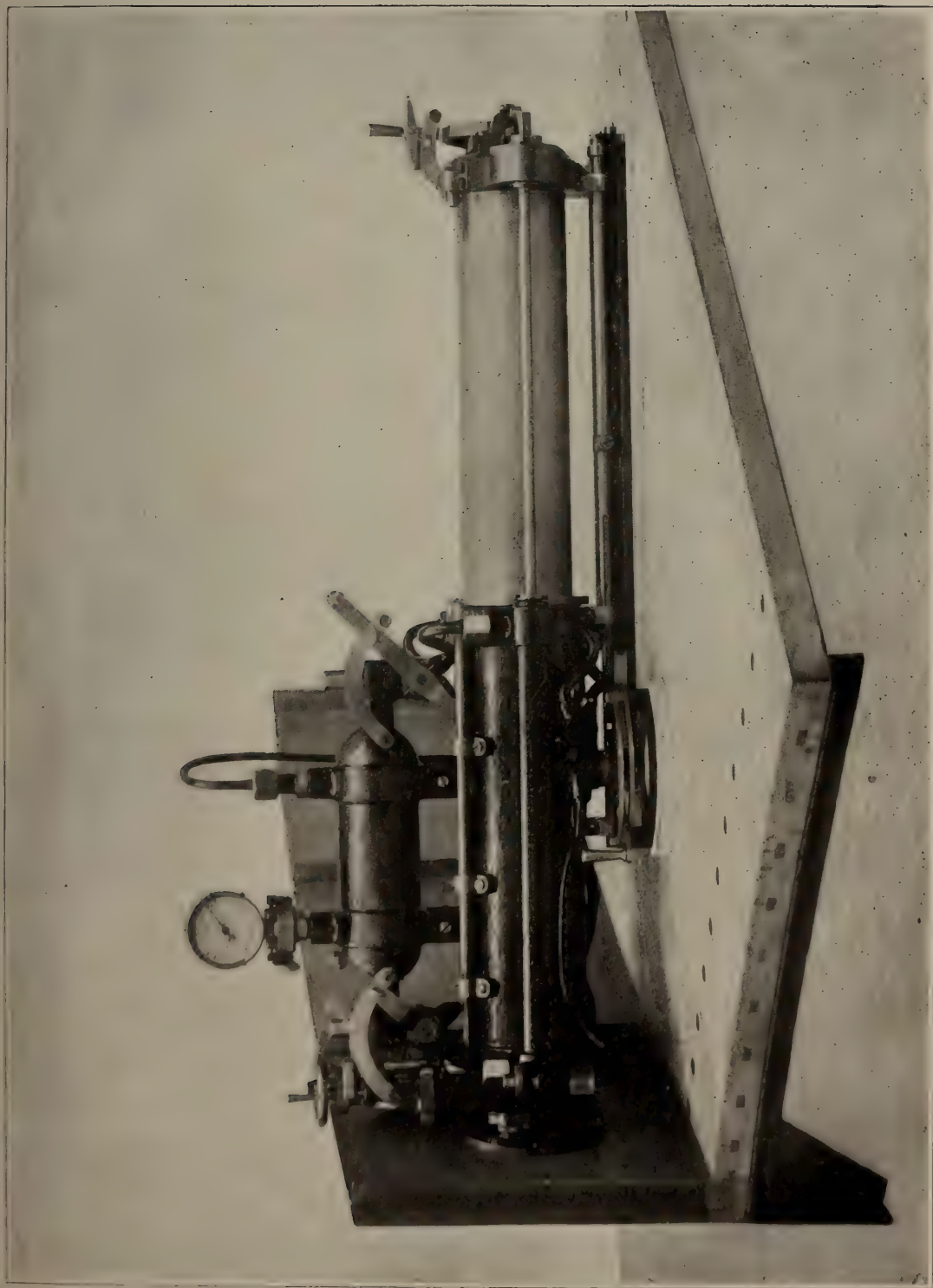


FIG. 6.—SCHWARTZKOPFF SUBMERGED TUBE FOR BROADSIDE DISCHARGE.

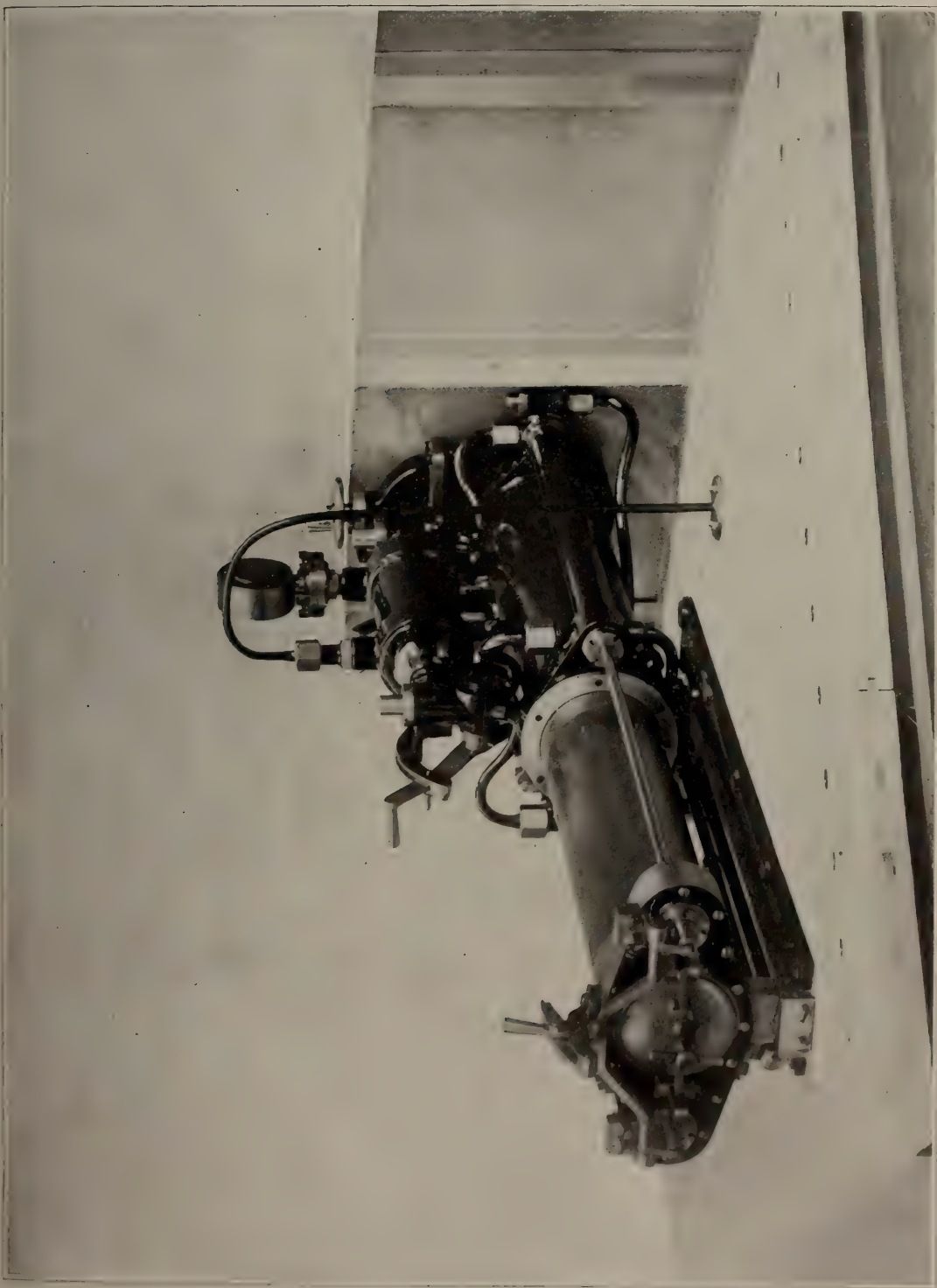


FIG. 7.—SCHWARTZKOPFF SUBMERGED TUBE FOR BROADSIDE DISCHARGE.

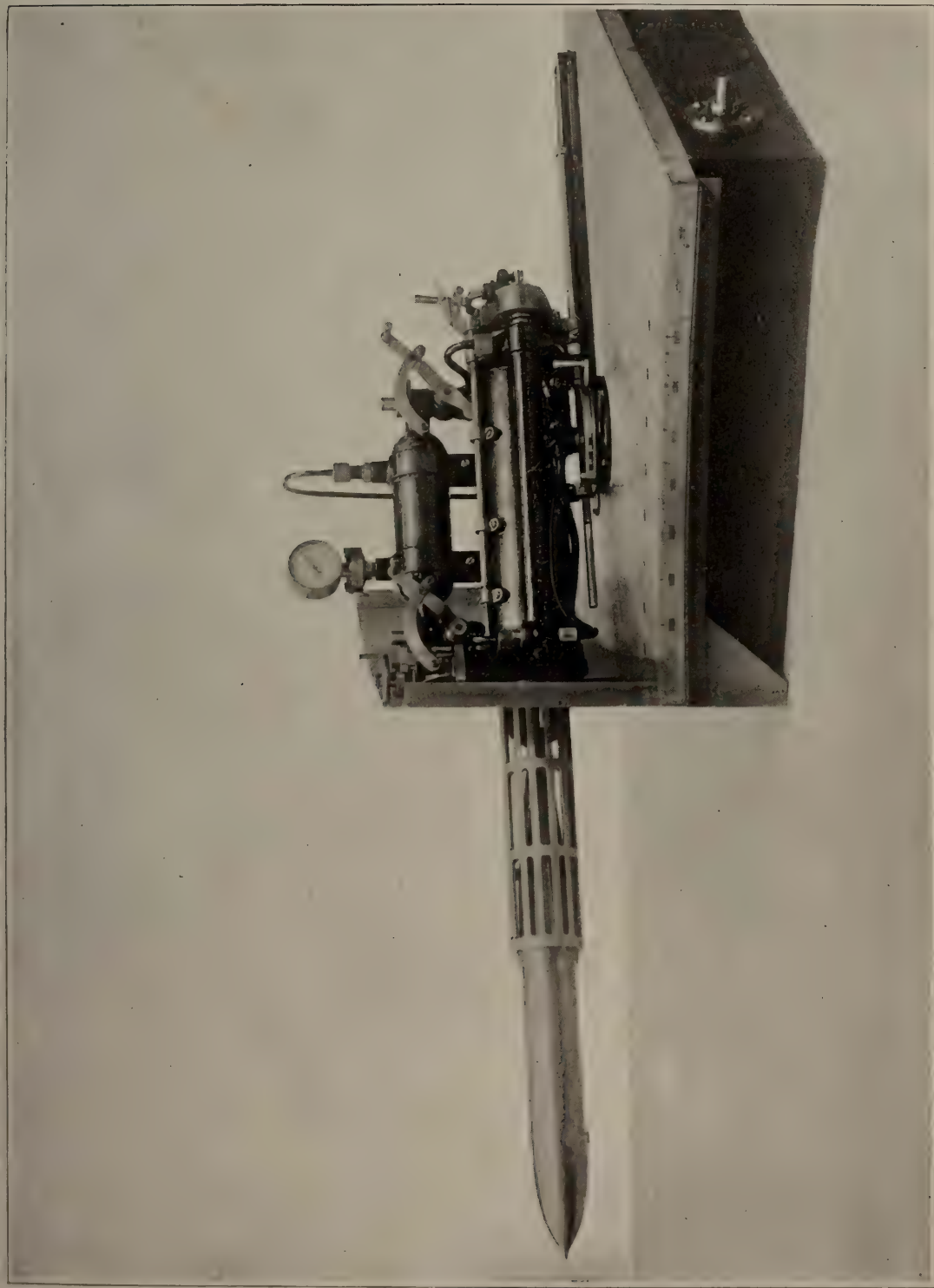


FIG. 8.—SCHWARTZKOPFF SUBMERGED TUBE FOR BROADSIDE DISCHARGE.

SECTION VIII.

ACCIDENTS.

12-INCH GUN EXPLOSION ON BOARD H. M. S. MARS.

A serious explosion, resulting in severe loss of life, took place on board H. M. S. *Mars* off Queenstown on April 14, 1902.

The Channel Squadron was engaged in carrying out the usual target practice, each ship firing at a target towed past her by another ship.

The *Mars* had completed her practice except that of the forward turret guns.

During the practice of these guns an explosion took place, resulting in the death of 2 officers and 9 men and severe injuries to 7 others, some of whom, as a result of their injuries, have since died.

The forward barbette of the *Mars* contained two 12-inch, wire-wound, breech-loading guns, fired by electricity. The port gun was the one in which the explosion took place, under the following conditions:

The gun had been loaded with a reduced charge of cordite and the breech closed. Several missfires had occurred and the order was given to change from the main to the auxiliary firing circuit, which order was carried into execution. The order to fire was executed with the result of a hang fire or a missfire, probably the former, and after waiting the prescribed five minutes, as called for in the British regulations, the breech was opened. Immediately upon the opening taking place, a tremendous explosion occurred. The starboard gun was loaded at the time, but was not discharged or injured by the explosion.

Of the 18 men in the turret, all were killed or injured, some of them being blown in fragments through the manhole. Upon the barbette being opened many of the men were found to be alive, but, it is stated, owing to the poisonous fumes of cordite, died almost immediately.

An examination of the barbette disclosed the following:

1. Breechblock disabled; extent not stated.
2. Projectile moved 5 feet in direction of the muzzle, where it remained jammed in the rifling.
3. Otherwise, the port gun showed no marks of the explosion.
4. Starboard gun: Load intact; not injured.
5. Barbette practically uninjured.
6. Rammer room to rear shattered.
7. Bodies of the guns' crews served as buffers to preserve rear of barbette.

CAUSE OF THE EXPLOSION.

At the moment of writing, no official report upon the accident has been published, and the following information is obtained from the various and somewhat conflicting reports. The first theory is that the accident was due to a "hang fire" of the cordite charges. The full charge of cordite for guns of the *Mars* type is made up in four sections, each part weighing 41 pounds 13 ounces, making a total of 167½ pounds in all. Each section is incased in a bag.

The *Mars* was using reduced charge, composed of two of the sections referred to above. As this reduced charge does not fill the powder chamber, it must be carefully entered so that the end of the charge when the breech is closed shall touch the breechblock and rest against vent.

It is stated that the charge was probably some distance away from the vent and failed to receive the full effect of the primer upon its being fired, so that only a portion of the cordite's bag was ignited. This smoldered slowly, there not being sufficient oxygen in the chamber to give the small flame a chance to spread and reach the ignition charge. Upon the breech being opened, air entered and the explosion took place.

The fact that the projectile was not forced out of the gun shows that little resistance was offered by the breechblock, which may have been opened, or swung to and entered but not locked.

Another report states that the breech was not properly closed. The mechanism of the gun in question requires three movements to close it, all of which are automatically performed by revolving a hand wheel at the side of the breech. The first phase swings the plug to, the second enters it, the third rotates and locks it. After firing several rounds the last operation requires more exertion than the others, and it is supposed that only the second motion was complete when the wheel brought up. In the desire to obtain rapidity of fire, the fact that the plug was not locked was overlooked and the gun fired. Firing circuits are usually constructed to prevent ignition of the charge until the breech is properly locked, but it is known that in the guns of the *Mars*, while the main current will not ignite the cartridge if the breech is not properly closed, the auxiliary current will.

The Admiralty have directed that the auxiliary circuit is not to be used in 12-inch guns up to the Mark VIII pattern, the 13.5-inch and the 16.25-inch until modifications have been made in the existing auxiliary firing arrangements.

NOTE.—Since the foregoing notes on the accident on board the *Mars* were written, the following official account of the results of the investigation by the court of inquiry have been given out by the Admiralty: "It was clearly proved that the accident was primarily due to the gun having been fired by means of the auxiliary circuit and to the breech not having been properly closed after reloading.

"The threads in the breech screw were found intact. The screw had been fully

ACCIDENT DURING TRIAL FIRING OF A 15-CENTIMETER (6-INCH) GUN AT BOFORS, SWEDEN.

On February 25, 1902, a serious accident occurred with a 6-inch gun at the proving ground of the Bofors-Guttspar Company, near Bofors. From an ordnance point of view, this accident is of special interest, for the reason that the cause of the same is to be sought in a defect inherent in a screw-closure system. The facts are briefly as follows: This 6-inch gun M 89, being one of those which had formed part of the former armament of the battleships *Svea*, *Göta*, and *Thule*, and are to be used in future as coast and fortress guns, had been remodeled by reducing the chamber to fit it for the use of smokeless powder and putting in screw closures. The gun in question was to be tried once more, as the trials which took place last summer had not given satisfactory results. At the same time the new brass cartridge cases were to be tested, as the cartridge cases obtained from France had proved unserviceable. The strength of the tube and breech was tested first by seven rounds of black powder, with gas pressures varying between 1,800 and 2,900 atmospheres, and were pronounced satisfactory. The cartridge cases, which were then tested by firing 8 or 9 rounds with charges of 9.65 kilogrammes (21.2 pounds) Nobel powder, with a very even gas pressure of 2,000 atmospheres and an initial velocity of 700 meters (2,296 feet), were likewise found satisfactory. Thereupon a rapid-fire series of 6 rounds with 9.65-kilogramme charges of Nobel powder was to be fired. It was at the fourth round that the accident occurred, which resulted in the immediate death of four men, who were killed instantly, and in the death of one who died the next morning. One man was slightly wounded. The discharge took place before the breech had been closed, probably immediately after the swinging in of the breech, before the breechblock had been turned and the screw threads of the latter locked with those of the gun. The investigation made the same day that the accident occurred showed that the screw threads of the gun as well as of the breech screw were intact. The breech screw, weighing 70 kilogrammes (154 pounds), had been hurled 500 meters (1,640 feet) to the rear by the premature discharge. The probability is that the screw threads would have been injured if the breech screw had been partly turned and the screw threads had locked. On the other hand, the firing pin was broken, which circumstance makes it probable that the point of the firing pin had projected over the front face of the breechblock, so that when the breech was swung in the point struck violently against the fuse plug in the base of the cartridge, thus causing it to burst instantly and the shot to be discharged, before it had become possible to turn the breech screw.

entered, but not turned. None of the threads were engaged in those of the gun, whereby it was prevented from being fired by the main circuit, though it could be, and was, fired by the auxiliary circuit, both slots and bolts of which were found connected.'

The Kriegstechnische Zeitschrift comments as follows:

Similar accidents have occurred frequently in connection with screw closures, and will continue to occur as long as screw closures and ignition in the axis of the bore in connection with metal cartridges are continued to be used. Judging from previous experience, it is not probable that means will be found for obviating this drawback, which is inherent in the mechanical principles of the screw closure. If this were possible it would have been done ere this, in view of the numerous accidents resulting from the same cause. We will only recall the accident on board the English battleship *Royal Sovereign* in November, 1901, in which 1 officer and 6 men were killed and 13 others wounded. Under the same circumstances, 4 men were killed and 4 severely wounded by the blowing out of the breechblock of a 14.9 centimeter gun on board the Italian gunboat *Terrible* at Spezia, in January, 1901. The latest accident of this nature occurred only a few weeks ago, on April 14, 1902, on board the British battleship *Mars*.

Such accidents are precluded where wedge closures are used, because the wedge, which, when the breech is being closed, moves vertically to the axis of the bore, does not put the firing pin in the direction of the axis of the bore, and hence in the position for ignition in the rear of the fuse plug, until the wedge is firmly lodged in the tube. Another important circumstance to be taken into consideration is that the cartridge can never receive a shock from the closing of the wedge closure, such as exerted upon the base of the metal cartridge by the closing of the breechblock of the screw fermeture, especially when in loading by hand the cartridge has not been pushed entirely into the tube. This is frequently the case in rapid fire when the man putting in the cartridge has to push his arm into the tube (the screw closure does not admit of a loading hole like the wedge closure) and must be careful to withdraw his hand quickly from the tube so as not to be caught by the breech screw when it is swung in. This explains how the breechblock upon the closing of the breech may push the cartridge into the chamber with a more or less violent shock, according to the rapidity of the swinging motion. This shock of the breechblock against the cartridge has in similar accidents caused the shot to be discharged, and may thus be not only the indirect but also the direct cause of the premature bursting of the charge. In wedge closures such shock is precluded, because, owing to the sloping face of the wedge at the loading hole, the cartridge is pushed into the chamber gradually.

In France, where the screw closure has been carried beyond the first phases of its development, the defects inherent in its principles have been conceded, as may be assumed from the eccentric screw closure of the rapid-fire gun C/97, since this closure, judging from the manner in which it works, may be considered a disk-shaped wedge closure with circular motion, as distinguished from the prismatic wedge closure with rectangular motion.

ACCIDENT TO A 6-INCH GUN ON THE "ROYAL SOVEREIGN."

By the explosion, during target practice, before the breech was properly closed, of the charge of a 6-inch gun, 6 men were killed and 19 wounded. The court of inquiry investigating the accident reported it as due to a fault in the breech-loading apparatus. It appears, that owing to a missfire, a new striker was being inserted, and that the breech plug was prematurely swung to before the operation of inserting the safety device had been completed.

The striker was not properly in place, but protruded so far that when an attempt was made to close the breech, an explosion occurred before the plug was locked.

Another report states that an electric primer had failed, and a percussion primer was substituted therefor. Upon the breech being swung to a premature explosion took place.

Details of the accident, other than the foregoing, have not been available.

EXPLOSION ON BOARD THE DANISH GUNBOAT MOEN.

In September, 1901, the administration of the Danish navy wished to carry out some experiments with explosive shell on board of ships. To that end 20 rounds were to be fired from the 26-centimeter (10.24-inch) gun of the old gunboat *Moen* and 30 rounds from the turret guns of the battleship *Skjold*. Both ships were at anchor beyond the Fort Mittelgrund in the northern channel. The firing was to be commenced on board the *Moen*. The 20 shells had been stored in the powder chamber situated under the gun, each shell filled with 26 kilograms (57 pounds) of picric acid. The cartridges, with an aggregate of 600 kilograms (1,322 pounds) of powder, were likewise in the powder chamber.

As a precautionary measure the men were all transferred from the *Moen* to the *Skjold*, anchored about 400 meters (437 yards) distant, from where the gun was fired electrically. The *Moen* had steam up. There does not appear to have been much confidence in the shell from the outset, for at the first two rounds all the men on board the *Skjold* were sent into positions of safety. At the third round there was a tremendous explosion. The whole forward half of the *Moen* was blown into the air, while the after half sank in a few minutes. Beams were hurled as far as the *Skjold* and splinters hurled down upon her, driving the men hurriedly back to the positions of safety which many had left when two shells had worked all right. No one was injured. It was ascertained by divers that the whole forward half of the ship had been blown into atoms, including the 10.24-inch gun. The supposition is that the fuse did not work right and that the shell exploded in the bore and shattered the gun, causing the 17 shells and the powder to explode. The engine is said to have been a confused mass of ruins; the boilers probably exploded.

The old *Moen* had no value as a fighting ship.

THE TORPEDO ACCIDENT ON BOARD THE FRENCH BATTLESHIP JAUREGUIBERRY.

The accident took place on January 22, and resulted in the wounding of four men—one of them mortally. The following particulars are from the evidence tendered at the inquest on this unfortunate man.

The ship was about to exercise torpedoes and the crew of four were about the tube—an 18-inch one. The reservoirs of these are usually charged to 90 atmospheres, but before acceptance have to undergo a test up to 130 atmospheres or more. In this particular case, however, the torpedo was charged at 80 atmospheres only at the moment of

explosion. It was apparently being charged at the time. It burst without the slightest warning, fracturing both thighs of the torpedo artificer, who was standing nearest it, and giving him a violent concussion, from the combined effect of which he died. The other three men farther away were chiefly injured by being hurled on deck through the shock and rush of air.

The explanation of the disaster given at the inquest was briefly as follows: The torpedo thus charged "was exceedingly fragile, owing to the immense pressure upon the interior of the air chamber," and no torpedo in the French service when in this condition can be relied upon to stand a shock on the reservoir or its parts. By accident, or carelessness, this particular one was struck, the wall ruptured, and the explosion then ensued. Attention was drawn to a previous accident of a precisely similar nature on board the same ship. This was some years ago, and with a submerged tube. The torpedo in leaving the tube exploded, breaking the bar. So far as can be gathered from the somewhat conflicting reports that were current, this accident was attributed to the bar grazing the side of the air chamber. Last year's explosion in the *St. Louis* was attributed to a graze from the spoon—practically the same thing.

These three accidents give the impression that French torpedoes are exceedingly delicate things to handle. They are of the Whitehead pattern. Most, or all, are made at the Government factory at Toulon. This torpedo possessed the following characteristics:

Diameter.....	17.72 inches
Length.....	16 feet 5 inches
Speed	29.5 knots
Charge (gun cotton)	198 pounds

The impression prevails that the weight of the shell and fittings of this torpedo had been reduced in order to allow an unusually heavy charge of gun cotton to be carried.

AN EXPLOSION OF PARTLY MANUFACTURED BLASTING GELATIN.

On the morning of January 16, 1902, at the factory of Noble's Explosives Company, an explosion of partly manufactured blasting gelatin took place under the following conditions:

A car loaded with three wooden tubs, each containing $177\frac{3}{4}$ pounds of hand-mixed blasting gelatin left the filter house for the purpose of depositing the partly mixed explosive in one of the magazines, where it was to remain all night to gelatinize prior to machine mixing. On arriving at the switch opposite the wash house, the car left the rails and, during the operation of replacing it, the explosion occurred.

The bed of the car was 18 inches from the ground. The explosion tore a hole in the ground 20 feet long, 15 feet wide, and 3 feet deep, while the three men accompanying the car were blown to shreds. Nothing remained of the car.

From statements made by men in sight of the car, but not seriously injured, it would appear that the disaster was due either to concussion of the steel car wheels on the steel rails, or the action of the leading car man setting the switch with his hobnailed shoes, assuming in either case that some nitroglycerin, or partially gelatinized blasting gelatin, had been previously spilt.

The investigation resulted in a recommendation that the tubs used should be fitted with covers; that they should be right cylinders instead of inverted truncated cones, and that the steel nails in the shoes of the tram-car men be replaced by copper, or other soft metal.

The presence of nitroglycerin on the rail could be accounted for by its having been spilt during the derailment of the car, or by a small leak in the tubs. The weather was cold, and the mixture would be more liquid than otherwise would have been the case, gelatinization taking place more freely when the nitroglycerin is warm than when it is cold.

The three tubs were of wood, brass bound, and separated at the top edges by several inches.

PREMATURE EXPLOSIONS IN QUICK-FIRING GUNS.

In view of the frequency of premature explosions on board ship, the following comments, from the Army and Navy Gazette, are quoted:

The serious accidents which have repeatedly occurred during the last couple of years in England, France, Russia, and Sweden from premature explosions in quick-firing guns of larger calibers necessitate reliable explanation as to their cause and thorough research of means for their prevention. It is urgent that this should be done at once, because such accidents will evidently occur more frequently when the guns become worn by long service. Full light should be thrown upon all surrounding circumstances, without too much consideration for the feelings of constructors and without giving too much weight to the question of cost of changing the present systems in case these should be found faulty. If due explanation of the faults and of the means by which they can be corrected is too long deferred the change ultimately will become more expensive, the greater the number of guns of unsafe types that are meanwhile acquired, with the risk, of incalculable importance, that the gunners may become afraid of their own weapons.

The first step toward increased rapidity of fire was the adoption of breech-loading guns in lieu of the old muzzle-loaders. Many countries started with their own constructions of breech mechanisms, but since the French breech screw, with interrupted threads and with De Bange's gas check, proved superior to Krupp's wedge, to which De Bange's system could not be applied, most countries have, like England, adopted the French type for ordinary breech-loading guns of calibers from 3 inches upwards. Next to the mitrailleuses, or machine guns, real quick firing was first carried out in smaller single-barrel guns up to the 6-pounder, and the constructors of such guns gained the special detail experience of all the precautions which were found imperative for the safety of quick-firing guns using metal cartridges carrying their own means of ignition. For such smaller guns no trouble has therefore arisen from the use of metal cartridge cases, but when the necessity made itself felt to increase the rapidity of fire also of larger guns the difficulties commenced, several countries having tried to retain the interrupted screw in order to save expense, while

inserting into it new firing arrangements and other modifications expected to suit quick firing with metal cases.

This led to repeated accidents, and this system soon proved itself unsafe and unsuitable for quick firing, when the powder charges were put into metal cases, and for the following reasons:

(a) The breech screw, on being pushed home with considerable force, strikes the base of the cartridge case so hard that the primer can be ignited by vibration; it has been proved that when a blow strikes the base at certain distances outside the primer the wave of vibration is almost sure to ignite certain types of primers.

(b) The firing pin in the center of the breech screw is always in line with the primer in the cartridge case when the breech screw is pushed home; if the firing pin is fixed with its point outside the face of the breech screw (in case the firing pin is broken or held in that position by powder, dirt, or from other causes), the primer is struck and ignited by the protruding firing pin before the breech can be safely closed by turning the screw into the threads of the gun.

(c) Recent official trials have proved that if the firing pin is not thus fixed, but rests free in its groove with the point protruding, the primer is nearly always ignited by the inertia of the firing pin, held forward by the initial pressure of its spring, when the breech screw is pushed home with force against a cartridge case fully inserted into the chamber. The firing pin can often be inadvertently left in this position if it has slipped off the trigger comb; when certain parts of the mechanism may be broken; when the spring may accidentally not have been armed, etc.

(d) It may be said that accidents of this kind do not often happen, but they are sure to become more frequent when the guns become worn, and there appears to be no justification for continuing to make or purchase guns of a system which almost seems to invite accidents.

(e) Electric ignition for quick-firing guns with interrupted screw does not diminish the risk, because the contacts are also in line before the breech is closed, so that failure of electric action will cause ignition and premature explosion.

(f) In case of ruptured cartridge cases or pierced caps the interrupted screw does not allow of sufficient space for the escape of powder gases.

(g) Whenever premature explosions do occur before the breech is safely closed the accident becomes more disastrous, because the breech screw is held only by its hinge, and all the parts of the mechanism are projected out of the gun like so many projectiles.

(h) The inconvenience already experienced in ordinary breech-loading guns of this system of opening the breech by swinging the mechanism outside the gun becomes still more serious with quick firing; when the vessel rolls the breech screw is apt to swing to and fro like a banging door, with much risk of jamming the hands of the gunners.

For larger guns, above 6-inch caliber, metal cases may, perhaps, become too costly and quick firing anyhow difficult. In such guns the De Bange gas check gives much satisfaction and the risk of premature explosions can be minimized by introducing into the mechanism means of manifold safety, which, with ordinary rapidity of firing, there would be plenty of time for operating.

The most important question for the moment is how to make quick firing safe in medium-sized guns, calibers from 3 to 6 inches. Pending definite decision upon this question, it has been suggested as a necessity to reduce the rapidity of firing by instructing the gunners to avoid all quick and violent movements; this seems to be an unreliable makeshift, as such instructions will soon be forgotten when the gunners are exposed to the enemy's fire. It has also been proposed to use the De Bange breech without metal cases, but this makes any attempts at real quick firing quite futile and gives rise to other serious disadvantages. There will always be the danger of burning particles left in the chamber, unless it is carefully sponged out after each shot.

The accident on board the *Mars*, where metal cases were not used and ignition was effected by electricity, shows the danger of the silk bag, in which the powder charge was inclosed, being insufficiently ignited and left smoldering, until it flamed up on the access of air when the breech was opened. When a metal case is not used it is more difficult and takes longer time to ascertain that the projectile is fully home, failing which the erosion becomes greater, and it is possible that a shell with double-acting fuse may explode in the bore of the gun. The metal case is of considerable assistance for pushing home the projectile, and anyhow prevents the breech from being fully closed unless the projectile fully bears against the rifling. The powder can not be so well protected in other ways as in metal cases, and upon thorough investigation of the entire question it will probably be admitted that the use of metal cartridge cases is, perhaps, the most important part of a really effective quick-firing system.

Many attempts have been made in recent years to solve the problem, and it is of interest that while France was the first country in which the De Bange gas check was used, that country seems again to be first in adopting into its army as well as its navy the apparently safest breech mechanism for quick-firing guns with metal cases in the excenter screw breech mechanism which has been adopted for the new French quick-firing field gun, and which—like De Bange's breech—will probably soon come into general use in most countries.

The leading features of the system are said to be the following:

(1) The breech block is not pushed forward against the cartridge case, which is wedged into its proper position by the sloping surface of the excenter screw, thus removing the risk of premature explosion by vibration during the loading operation.

(2) The firing pin can never, even accidentally, be brought into line or into contact with the primer until after the breech is so far closed that no accident can occur from the firing pin accidentally striking the primer, or when fired electrically, from faulty electric action.

(3) There is consequently no necessity in the firing mechanism for any safety gear, which might be apt to get out of order or inadvertently become inactive.

(4) No risk is incurred from using metal cartridge cases carrying their own means of ignition if the primer is covered by a safety clip, which is removed only at the time of loading, or if the primer is inserted into the case after this is brought to the gun from the ammunition magazine.

(5) The powder charge is thus fully protected.

(6) As the breech can not be closed until the projectile is pushed home by the metal case, the erosion will be the smallest possible, as well as the risk of explosion of shells in the bore of the gun.

(7) In case of a ruptured cartridge case the powder gases are free to pass out through the open space into which the breech block is turned when the breech is opened.

(8) The eccentric breech block always remains in the breech, with as large a bearing surface for the threads when the breech is open as when closed; in the improbable case of premature explosion, the only piece that can be projected to the rear is thus the base of the metal case.

(9) The mechanism occupies no more space when open than when closed and there is no inconvenience for the gunners in a sea way.

(10) The excenter screw is used for several calibers, from that of field gun up to 5 and 6 inches.

The cost of metal cartridge cases over and above that of other means of protecting the powder charges, in the magazine and when carrying them up to the guns, is not of such great importance as has sometimes been said, because old cases would mostly be used for gun practice in time of peace. Anyhow, metal cases are better means of obturation than even De Bange's gascheck. Perhaps the best argument in favor of

mechanisms in which the cartridge cases are not subjected to blows and the firing pin is not brought into line with the primer until after the breech is closed, is the fact that while other countries are hesitating to use metal cases with the interrupted screw, Germany is said to contemplate the adoption of such cases for even larger caliber than 6 inches with Krupp's old wedge mechanism, which offers these two advantages, though in other respects not free from drawbacks.

If upon thorough investigation the above statement of the principal features of the excenter screw mechanism proves correct, that gun may be said to offer the greatest security against accidents, as its safety depends entirely upon the construction of its mechanism and is independent of any breakage of its parts, and of any failure of the gunners to follow instructions; or, in other words, that the gunners can not inadvertently make it dangerous for those who serve it.

III.

ENGINEERING NOTES.

By Lieutenant CHARLES L. POOR, U. S. Navy,
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GENERAL NOTES.

Since the issue of the last annual of this office, naval engineering has been developed and discussed most thoroughly in regard to boilers. There is little that is new to be recorded in regard to engines. There is an extended use of quadruple-expansion and four-cylinder triple-expansion engines. The question of triple screws continues to be agitated, and though the great weight of naval opinion seems to be against their use, the principle is gaining advocates, particularly in France, where most of the new large vessels are 3 screw, and in the German navy, where they have been tried with distinct success, and the German officers do not acknowledge entirely the most serious charge against the triple screw—reduced maneuvering powers. Recently, the battleship *Kaiser Wilhelm II*, while passing three times through the Kiel Canal at low speed, was controlled with great ease by the following novel method:

By going ahead at a speed of 5 knots with the middle screw and backing equally on both side screws at 3 knots, the vessel had a net speed ahead of 2 knots, when the ship was under as perfect control as when steaming fast. The water thrown against the rudder was that for a 5-knot speed.

Modern engineering practice, with its high steam pressures and great piston speeds, is being confronted with several serious questions in design, chief among them being those of safe and tight piping and joints and the proper balancing of high-speed engines. Considerable attention is being paid to these points, and during the past year a number of valuable papers and reports have appeared upon these subjects.

The progress of the steam turbine in naval engineering received a very serious setback last summer in the losses, within a short time of

each other, of the British destroyers *Viper* and *Cobra*, with which the Admiralty was to make exhaustive tests. The *Viper* had already undergone a series of successful trials and was rendering valuable service in the naval maneuvers at the time of her loss. The *Cobra* was on her way from the builders to be turned over to the Admiralty finally at Portsmouth dockyard, so that little data were obtained from her. Experience with the *Viper* showed that higher speed could be realized with turbine engines than with ordinary engines in a destroyer with similar dimensions and form. Turbine engines do not occupy less space necessarily than vertical engines, but they are much less in height and can much more easily be kept below the water line. They are almost entirely free from vibrations, but they required a greater engine-room and boiler-room complement in the *Viper* than in ordinary destroyers of the same size.

In mercantile engineering the steam turbine has been very successfully applied in the 250-foot Clyde passenger steamer *King Edward*, in which three compound steam turbines were installed side by side. Each turbine has its own shafting and on each of the wing shafts there are two propellers, while the center one carries only a single screw. When coming alongside a pier or maneuvering in close quarters the wing motors alone are used. The high-pressure turbine is then shut off, the steam admission valve being closed, while connection between it and the low-pressure turbine is also shut off by an automatic arrangement.

There are special turbines placed inside of the exhaust ends of the low-pressure turbines for going astern with the wing screws. The whole of the maneuvering, except, of course, for the rudder, is effected by manipulation of valves in a simple manner. The feed and circulating pumps and blowers are worked separately. The main air pumps work by worm gearing from the wing shafts, but there are auxiliary air pumps actuated by the circulating pump engines, for use when not under way. The weight of engines, propelling machinery, condensers with water in them, etc., is said to be about half the weight, per ton I. H. P. developed, of the average machinery of paddle boats of a similar type. The vessel was handled and controlled with great ease in service on the regular trips.

The British Admiralty is determined to carry on experiments on an even greater scale with turbo-motors, and a notable step has been taken in their decision to fit a new third-class cruiser, to be built at Elswick with Parsons turbines. A sister vessel to be built at Birkenhead is to have ordinary reciprocating engines, so that we shall have an excellent opportunity to judge from thorough comparative tests the relative merits of the two systems. The new vessels are to be 360 feet long, 41 feet wide, and 14 feet 6 inches draft, $21\frac{3}{4}$ knots speed, and 3,000 tons displacement, which craft should be large enough to afford us more

reliable comparison than destroyers. The specifications call for 18 I. H. P. per ton of machinery, which calls for about the highest convenient attainment, and puts the Parsons turbine to a severe test.

In addition, the Admiralty has purchased the 210-foot turbine destroyer *Velox*, which presents the novel features of having both turbine and reciprocating engines.

In general design of the hull she resembles an ordinary destroyer of the most recent class, but especial attention has been paid to the strength of the structure; indeed, the builders claim she is the strongest destroyer yet built. The main propelling machinery is substantially similar in principle to that which has been placed in other vessels having Parsons steam turbine engines. There are two sets of compound turbines, one on each side of the engine room. The high and low pressure turbines have each, respectively, their own shafting; so there are four shafts, and on each shaft are two propellers. These are the main engines for high-speed steaming, but for ordinary cruising the auxiliary propelling system is brought into play. It consists of two small sets of triple-compound marine engines of the ordinary type, which are coupled directly to the main turbines, but can be disconnected at will. Steam is taken directly from the boilers to these small engines, and from them it passes to the turbines, and in this way to the condensers. That is for the low-cruising speeds; but when a somewhat higher rate of steaming is required, steam from the boilers is also admitted to the turbines. When, however, the maximum power has to be developed, and the propellers would be running at a rate of turning at which it would be unsafe to try the reciprocating engines, the latter are thrown out of gear and the turbine engines alone are used. The advantages of the system are manifest. An engine designed for the full power required for moderate speeds will naturally be more economical than one far too big for the purpose. The practical working out of the idea will be watched with interest. For reversing purposes blades are fitted in the exhaust casing of the low-pressure cylinders. The boilers are of the modified Yarrow type, and are the same as those fitted in the 30-knot destroyers, being about 13 per cent smaller than the *Viper's* boilers; they have a total heating surface of 13,000 feet. It is, however, anticipated that the new vessel will have about the same speed as the *Viper*. Arrangements are to be introduced in the shape of feed heaters, etc., for securing high economy.

Considerable attention is being paid abroad to the construction and equipment of steam launches and vedette boats supplied to men-of-war. Much improvement has been effected in speed and weatherly qualities in these small craft.

During the summer of 1900, when the vessels of Great Britain, France, Russia, Germany, Italy, Japan, Holland, Austria, and the

United States were gathered together in the Gulf of Pechili, in north China, there was an excellent opportunity for observing the seagoing qualities of their launches under all conditions of weather. It was the general opinion then that the Austrians had in their 47-foot half-decked launch the most seaworthy type of all. They remained down at the boom or cruising about when the boats of the other vessels had to be hoisted inboard, and in such weather that an English launch was swamped alongside of her ship.

The following notes on English and foreign launches are copied from a lecture by Mr. E. C. Carnt, read before the Glasgow International Engineering Congress, 1901:

From 1883 onward the progress made in marine engineering and shipbuilding has been reflected on the designs of the small craft under review. Changes have gradually been made in the 56-foot boat design, the hulls have been modified, a rifle-proof conning tower has been fitted forward, the side air casings or lifeboat principle has been abolished, and the boats divided up into water-tight compartments by bulkheads. The engines and boilers are cased over, and the boat decked in right aft to the cockpit. The indicated horsepower has been increased, water-tube boilers substituted for the locomotive type, and as a result the 56-foot service vedette boat of to-day will travel at 16 knots while developing 250 indicated horsepower, carrying a load of 12 persons and with 25 hundredweight of coal in the bunkers, the weight of machinery with steam up being 7 tons 15 hundredweight. The turn-about principle has been retained, and this very fast, handy type of boat might easily be called the "hansom cab" of the fleet as compared with the next size, the useful, hard-working "four-wheeler" 40-foot pinnace. This boat is a deadwood boat as distinct from a "turn-about," has a specified indicated horsepower of 75, and obtains a speed of about $9\frac{1}{2}$ knots.

It is decked in and machinery cased over as far aft as the cockpit; the lifeboat principle of air casings is discarded except in the fore-part, abaft the collision bulkhead; the boat is, however, divided into water-tight compartments by bulkheads carried right up to the deck. The engines run at 500 revolutions; the boiler is of water-tube type, and is worked under forced draft on the closed-stock-hold system, a separate fan engine being fitted. The engines are surface condensing, a pipe condenser being placed outside the boat close to the keel. These boats are fitted with offensive weapons, torpedo-dropping gear, and a small gun.

In flagships a modified 40-foot pinnace is carried as a barge for the admiral commander in chief, unless the flagship has no boat-hoisting derrick, as in second-class cruisers, when a 32-foot barge only is carried.

The barges are more ornamental than the pinnaces, and have no armament fittings. The other standard steamboats are the 32-foot cutters and 32-foot barges, 27-foot cutters, and 23-foot cutters. These, from the 32-foot boats downward, greatly resemble the 32-foot lifeboat pinnace built in 1867, except that the lifeboat principle is not always followed, although the steamboats of the new *Victoria and Albert* are on the old lines, and lifeboats throughout.

The surveying boats are also lifeboats.

The machinery of the various sizes of boats has been brought up to date, the engines compounded, a pipe surface condenser fitted outside the boats, and a fan worked by a steel spring belt from the main engines discharges air into the ash pits. The boilers are of much the same type as the 1867 boats, but, working in conjunction with condensed water, are more efficient and last longer than in the old high-pressure days.

The noise of the funnel exhaust, together with its occasional shower of sooty water from the top of the funnel, are things of the past.

The establishment of boats of the various classes of ships in the British navy is as follows:

	Pinnaces.		Barges.		Cutters.		
	56 ft.	40 ft.	40 ft.	32 ft.	32 ft.	27 ft.	23 ft.
First-class battleships	2	1					
First-class battleships, if flagship	2	1	1				
First-class cruisers	1	1					
First-class cruisers, if flagship	1	1	1				
Second-class cruiser					1		
Second-class cruiser, if flagship				1	1		
Third-class cruiser						1	
Torpedo gunboat	}						1
Sloop							
Surveying ship						1	

With the construction in this country of war ships for foreign navies, the question of equipment of steamboats is brought forward, and we find the Japanese navy adopting two 16-knot 56-foot vedette boats and an open boat, as the steamboat equipment for the battleship *Mikasa*, building at Barrow by Messrs. Vickers, Sons & Maxim.

The Russian Governments require two 56-foot vedette boats and two 40-foot pinnaces for a vessel building for them in France. These four boats are of steel, and very fully equipped.

The Austrian Government uses a 47-foot wooden turnabout boat with a speed of 11 knots, and are now adopting a specially fast wooden vedette boat 56 feet in length.

In connection with the vessels recently built by Messrs. Armstrong, Mitchell & Co. for the Japanese navy, four 56-foot vedette boats were required.

Messrs. Armstrong, being always in the front where speed is wanted, asked us to consider the possibility of giving these four boats a speed of $17\frac{1}{2}$ knots under certain specified conditions.

These required careful looking into, and the final design became a 56-foot boat, with a ram bow which increased the water-line length about 9 inches.

The hull was very carefully lightened consistent with durability where possible, and the total weight of machinery kept down to 8 tons. The engine was compound,

with $\frac{8\frac{1}{2} \times 18}{9}$ cylinders. A water-tube boiler of our own type, with a working pressure of 190 pounds, was fitted.

On our own private trial the boat gave us an exhibition of speed that we scarcely hoped for, viz, $19\frac{1}{2}$ knots. The engines developed 320 indicated horsepower at 565 revolutions without vibration.

A series of progressive trials were carried out with this first boat, the results of which are plotted on the curve attached on the official trials of the four boats, with the load conditions as specified. The mean results were as follows:

	Revolutions.	Indicated horse-power.	Speed.	Date.
No. 1	548	297	18.322	May 2, 1900.
2	540	297	18.1	Do.
3	538	302	18.25	June 6, 1900.
4	543	292	18.32	Do.

These four boats are, we believe, the fastest vedette boats in the world.

We are building a similar boat for the Austrian Government. This will shortly be completed, and we anticipate equally satisfactory results.

You will notice that even so far back as 1864 the revolutions of the engines were high (278 per minute), and that they have still increased until at the maximum speed of the four boats for the Japanese navy we are running at 565 revolutions per minute, with an open 2-cylinder compound engine, with carefully arranged balance weights on two cranks at right angles to each other.

Familiarity and experience with such fast-running engines undoubtedly led Messrs. Belliss & Co. (now Messrs. Belliss & Morcom), who, as we have seen, constructed all the machinery for Mr. White's boats (up to the year 1899, when an engine works was started at Cowes in connection with the ship and boat building shops), in the direction of their "quick-revolution, electric-light machinery," a later development of which is closing in the engine and applying forced lubrication to the bearings, with a view to running for long periods at a high number of revolutions without excessive wear and tear. This class of machinery is doing its work satisfactorily for electric-light stations and on shipboard; and now a 30-knot torpedo-boat destroyer, built by the Palmer Shipbuilding Company, of Jarrow-on-Tyne, fitted with a forced lubrication system, and with engines closed in, is about to be officially tried in the *Solent*.

We have looked into this class of machinery for the fast vedette boats, and have a design ready for use; but as we are already running up to 560 revolutions with an open engine, it will probably be some time before this number will need to be increased; and as the matter of wear and tear is hardly one which seriously affects boats with small coal supply and running short trips, it becomes a question whether it is necessary to close in a small engine and make it less accessible for examination.

The Admiralty boats are all built of teak, and undoubtedly this is a most serviceable wood for all conditions of service and exposure to tropical weather; but in all the early boats mahogany was invariably used, and we now prefer it for high-speed boats, as it makes, size for size, a lighter hull, and may be considered, for all practical purposes, equally durable.

COALING MACHINERY.

The Spanish war showed the necessity of devising some means whereby vessels might be coaled at sea or during blockade. The question had been attacked prior to this, with but little success, both by Great Britain and France. Nearly twelve years ago it was attempted and accomplished in mid-Atlantic by Admiral Sir Michael Culme Seymour. The ships were, however, stationary. Since then the French have tried the same thing under way.

The first coaling at sea took place in the middle of August, 1890, some 500 miles south of the Azores, and 1,000 or more from the African coast, with 2,000 fathoms under the ships' bottoms. Thus all the conditions of being at sea were amply fulfilled.

The ships that coaled were the *Camperdown*, *Ajax*, *Audacious*, *Iron Duke*, *Northampton*, *Immortalité*, *Aurora*, *Neptune*, *Conqueror*, and *Minotaur*. They took varying amounts—in all cases the minimum necessary to take them back to Torbay, some 1,800 miles distant. One ship, the *Howe*, evaded coaling, and had to go into Vigo; the rest, though their captains protested strongly in several cases, took coal.

There were three full colliers with the fleet, and each ship took an average of 350 tons, at the usual harbor rate or nearly so. The sea was smooth to look at, but there was a heavy Atlantic swell. Each collier was lashed alongside a battleship, with thick fenders between. Toward the end of the operation the swell increased, and a considerable amount of "moral suasion" was required with at least one collier captain. The coal was taken in with derricks at the main-deck ports. One or two ships had torpedo booms broken, and one collier sustained some dents in her sides; but no material damage was done. The ships were kept bows on to the swell, and so there was no rolling. All, however, pitched somewhat, and the colliers, when they began to get light, pitched rather violently. It was this pitching which did such damage as was sustained. We have dealt with this sea-coaling at some length, because, so far as we know, it was the first effort ever made in this direction. Its strategical value was, or rather might have been, great, the fleet that coaled being an evading one; and had not the *Howe* put into Vigo to coal, it would, thanks to this coaling, have completely achieved its object—the destruction of a mythical trade without its whereabouts being known to an enemy who trusted to discover it by its having to go and coal.

French experiments have gone on intermittently ever since 1890 with vessels under way, the collier being lashed securely to the ship, and then the latter steams ahead, against the wind generally. It is claimed that 10 knots has been reached in some of the trials, though this was necessarily in smooth weather, and it is even doubtful if this speed was reached. Use was made of Temperley transporters in these experiments.

The experiences of the Spanish war gave a great impetus to the solution of this problem, and recently the Russian and British navies have been experimenting with systems for coaling at sea. The Russian battleship *Retvisan* has been fitted with a Lidgerwood-Miller cable way. The traveler is operated by portable electric winches, which may be transported about the deck to positions favorable for working the cable way at sea. In addition, there is a hoisting device for taking on coal from colliers alongside in harbor. So equipped, the *Retvisan* may either tow or be towed by the collier.

The British Admiralty has been carrying on a series of experiments with the Temperley-Miller cable way, originally devised and successfully operated by Mr. Spencer Miller.

He cooperated with Mr. Temperley, whose transporters are in general use in the British navy for coaling purposes, with the result that with improved appliances the problem appears to be near solution. The collier *Muriel*, which was sent to Portsmouth last July, was fitted with a large square mast, from the top of which a cable way extends to the quarter-deck of the ship to be coaled. For the purposes of the

experiments, the *Trafalgar*, port guard ship at Portsmouth, was supplied with the necessary gear, and after several preliminary trials of an initial character, the *Trafalgar* put to sea towing the *Muriel*, whose engines were so slowed down that they did not give the ship steerage-way. The *Trafalgar* then steamed head to wind at a speed varying from 8 to 10 knots, but from time to time one ship or the other sheered off a straight course and so reduced speed of coaling. The *Trafalgar* having with two hawsers taken the *Muriel* in tow, the main cable was hauled on board the *Trafalgar* and made fast to her mainmast about 10 feet below the fighting top. The tail block, through which the traveling line passed, was sent to the *Trafalgar* along the main cable and made fast about 4 feet below the main cable on the *Trafalgar's* quarter-deck about 100 feet abaft the mainmast. A guidepost was erected, through which both these ropes passed and were so adjusted that, controlled by fair leads, they could slide up and down a distance of about 30 feet. Parenthetically it may be mentioned that any war ship supplied with the guidepost as tried in the *Trafalgar* can get into communication with a collier at sea, and there is no need for boats or other laborious methods of conveying cables from ship to ship. As soon as the ropes had been made fast coaling began, and six bags of coal, each containing 2 hundredweight, were sent from the deck of the collier to the mast head by means of a lift working on rails on the side of the mast, and were then transferred to a traveler. The traveler containing the six bags of coal was then drawn across to the battleship by a steel-wire rope, which was coiled in by an engine. On reaching and striking the tail block in the *Trafalgar* the load was released and fell on the deck of the battleship. The empty trawler was then drawn back to the collier by another wire rope, worked by another engine, and at the beginning of the return journey the fair leads were hoisted to the top of the guideposts by the upward strain of the main cable and secured in this position. When the traveler approached the guidepost on its next journey the fair leads were released and the load gradually reached the deck of the battleship.

Instead of using a sea anchor to keep an equal strain on the main cable between the vessels, as in former experiments, the same result was ingeniously accomplished by the use of a main cable tension engine which automatically keeps the cable taut while permitting its length to vary. This engine has two 13 by 13 inch steam cylinders, and is geared to a slipping drum. The engine turns in the same direction all the time, and the slipping drum is given a definite power of about 5 tons by the slip of its friction heads. Hence the drum maintains a constant pull on the main cable revolving one way and then the other as the movement of the ship requires greater or less length of cable.

The two ships were 350 feet apart, measured from the bow of the



FIG. 1.—COALING AT SEA.



FIG. 2.—COAL BAGS IN THE ACT OF DROPPING.



FIG. 3.—THE TEMPERLEY-MILLER TRANSPORTER AND CABLE WAY.



FIG. 4.—COLLIER MURIEL WITH ITS RAILWAY UP MAST AND SENDING COAL TO TRAFALGAR.

Muriel to the stern of the *Trafalgar*, and a steady head to wind course was pursued to prevent the collier from drifting on to the battleship. The operation lasted two hours and fifty-five minutes, and in this time 89.8 tons of coal, or an average of 30.8 tons an hour were transferred from the collier to the battleship. The quickest run was forty-seven seconds, or an average of 46 tons an hour, and it is believed that with further experience this rate of coaling at sea can be maintained.

The initial experiments were all carried out alongside the dockyard, and the last trial took place in favorable weather at sea, but it is expected that the next trials will be conducted in bad weather at sea, in order to give the apparatus a complete test before it is finally adopted in the service. At the trial, which was intended to demonstrate the practicability of the scheme, only six bags of coal were carried at each journey, but there is no reason why eight bags should not be carried, thus adding 25 per cent to the speed of coaling.

The accompanying photographs show the system in operation between the two ships. Fig. 1 shows the coaling operation at sea. Fig. 2 shows the first operations in port with a load of bags just being dropped from the transporter. Fig. 3 shows the transporter and cableway, and fig. 4 shows the mast of the *Muriel*.

LIQUID FUEL.

Much attention has been paid during the past year to the subject of liquid-fuel firing for marine boilers. The recent great discoveries of oil in Texas, California, Japan, and Canada, and the exploitation of the Borneo and Russian fields have given a great impetus to this branch of engineering. Hitherto the lack of fields and their practical monopoly by one or two nations have been a great hindrance to any extensive adoption of oil firing by nations not having fields of their own, and whose fuel supply might be cut off in war time. Indeed, this still acts as a barrier to the extension of the system on a large scale other than as an accessory to or in conjunction with coal burning.

Though Russia remains naturally the leading exponent of liquid fuel, and has exclusively adopted oil firing for her Caspian and to some extent for her Black Sea fleets, France, Italy, Germany, Holland, Sweden, and Great Britain have all been making thorough experiments in this direction.

In Great Britain the trials with the destroyer *Surly* have been continued throughout the year. This vessel (see No. XIX, p. 232, and No. XX, p. 280), fitted with Holden and Rusden & Eccles burners, uses oil as an auxiliary to coal. The burners, grate arrangement, and auxiliary fittings have been modified in various ways, but the vessel continues to give forth dense black smoke, whether Borneo or American oil be used. In fact, the smoke question, of little import in the merchant service, seems to be the most serious problem that the naval

experimenters have to face. Much would seem to depend upon the arrangement of the furnaces, which should be especially constructed for oil firing, with suitable fire-brick bridges and deflectors. It is claimed that smoke has been almost entirely eliminated in some of the Russian installations, and the Durr system, using Texas oil, is almost smokeless, so that the objection would not appear to be insuperable.

Great Britain is continuing the *Surly* experiments, and, in addition, has fitted one of the boilers of the cruiser *Blonde* for oil firing, while six of the boilers of the *Arrogant* are fitted for oil. It is further stated upon good authority that the battleships *Mars*, *Hannibal*, and *Resolution* are being fitted with oil burners. In all cases these are to be used in connection with coal and not alone. It is not stated what type or types of burners are to be used in these experiments.

The Swedish Government has entered the field by ordering from Yarrow & Co. a 31-knot torpedo-boat destroyer of the most modern type, to be fitted with oil-burning apparatus.

The Dutch Government, whose experiments with the *Ophir* were noted in No. XX, page 280, has conducted as thorough series of experiments with the sister torpedo boat *Pangrango*. The boilers of these boats are fitted with supplementary oil-burning apparatus, intended to be used as a reserve for short periods of time when extra speed is required. Ordinarily coal alone is burned. There are three of Holden's liquid fuel burners fitted to each boiler for this emergency operation. The oil is kept in a tank on deck, where, if pierced by shot, the oil would run into the sea without danger of fire in the interior of the boat. A steam spray is used to vaporize the oil. This saves the bulk and trouble of an air compressor, but it is a most undesirable feature on board torpedo vessels, where every drop of fresh water counts. In fact, the steam vaporizer is entirely out of the question for naval use, except as in the case of the vessel under consideration, where it is only used for a short time. The successful naval oil burner of the future will have to use some other method of vaporization. A number of types of burner of this sort are already in successful operation. On a trial with the *Pangrango* coal only was burned in one run. The air pressure was 1 inch; the stop valve was kept full open. The following were the results obtained: Boiler pressure, 150 pounds per square inch; pressure in first receiver, 54 pounds; second receiver, 5.5 pounds; vacuum, 23½ inches; revolutions, 340; speed, 24½ knots. The oil fuel was then started, and as much oil as possible was burned *without making smoke*, so important a consideration in naval warfare. The rate of combustion for coal was maintained as before. The following results were obtained: Boiler pressure, 180 pounds; first receiver, 64 pounds; second receiver, 9 pounds; vacuum, 23¼ inches; revolutions, 365 per minute; speed, 26½ knots.

Thus, by the use of oil, an increase of 2 knots was obtained, and almost instantaneously.

Borneo oil was used, the supply being at the rate of 700 pounds per hour for the two boilers. The total coal consumption was 2,800 pounds per hour in either case. The oil tank held about 1,100 pounds, or enough for one and one-half hours' run under the above conditions.

A feature that would prove of considerable importance in actual warfare would be the fact that the boilers could be worked at very high rates of evaporation although the fires were in a dirty condition. A torpedo vessel would often have to operate at some little distance from its base, thus necessitating a comparatively long run made at moderately high speed before the final spurt, preceding the discharge of a torpedo, were made. The result would be that grates would be clogged, and it might be even advisable to lay off and clean fires before proceeding to action. Such an operation, with the letting down of steam and the creation of smoke, would do very much to endanger the success of the attack; and yet high speed is one of the first essentials to surprise, which, in turn, is a necessary element of approved torpedo-boat practice. With the oil fuel, high speed can be maintained with dirty fires, and also with inferior coal. What is true of torpedo craft is also true of larger vessels under the conditions of service common to them.

It may be pointed out in connection with this matter that the jets for spraying oil into the fire box are placed at a considerably higher level, and consequently there exists, as it were, two layers of fire. The result is the same as if the grate area were largely extended.

On the trials no difficulty was found in avoiding smoke, this being simply a matter of adjustment between the air supply and the amount of oil burned. In a forced-draft stokehole this is easily accomplished so long as the stokers can see the tops of the funnels. It would also appear from observation that the rush of steam and oil vapor into the fire box has the effect of mixing up the gases in the furnace more effectually, and this in itself leads to the prevention of smoke and adds to evaporative efficiency.

The Dutch Government has for a number of years been making thorough tests with *astatki*, the residue of Russian or Borneo oil, using the Korting and Holden systems of burners to test them, the former being applied in a number of cruisers and revenue steamers and the latter in various torpedo boats. The Korting system is described in Sir Fostescue Flannery's article, appended. As modified and improved it was installed as follows:

Brak, Dog, and Husewind, revenue cutters for the Dutch East India Line, between PP. 131.24 feet, B. 22.64. Draft on trial, 7.45 feet;

displacement, 322 tons; displacement, fully loaded, 361 tons. Built in 1898.

Brak and Dog by Huygen and Gelder; engines of the Schelde. The *Hasenwind* by Fegevoord.

Description of boiler arrangements of revenue cutter *Hasenwind*: The boiler is of steel except the tubes and firebox stays, which are of iron. GS. 42.09, HS. 1,097.96 square feet.

Near the boiler stands a Tangey duplex pump; diameter of the two steam cylinders, 4.96 inches; diameter of the two pump cylinders, 2.99 inches. Stroke, 5 inches.

There are two Purcells furnaces, each having a separate combustion chamber. Each furnace has two burners placed on each side and above the furnace door. On the two other sides, however, they are placed in another separate door, which takes the place of the regular furnace door.

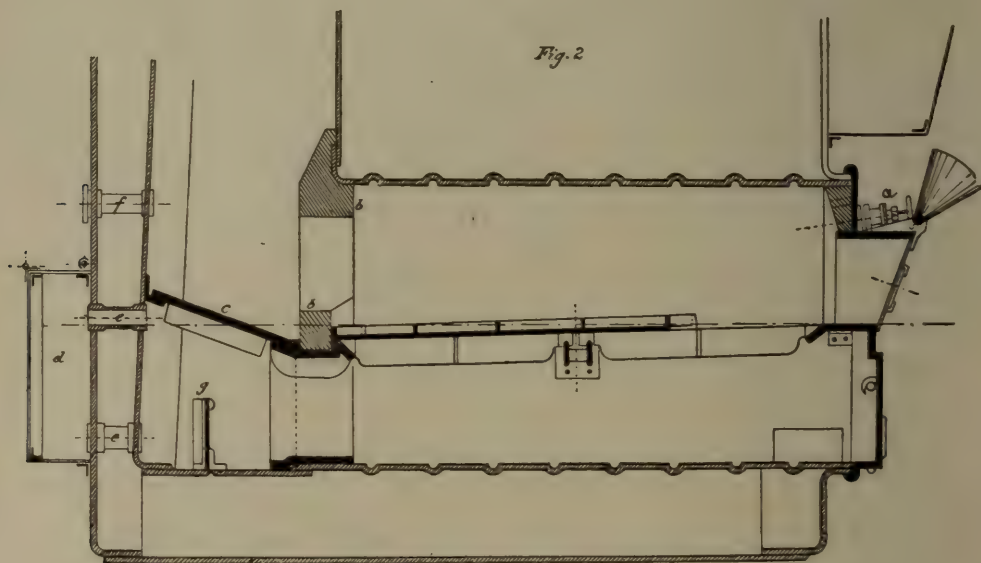


Fig. 2 shows: *a*, astatki burner, under which is a reservoir for collecting the astatki leaking out of the burners; *b*, fireproof bricks against the lower fire bridge; *c*, plate closing up the ash pit; *d*, air box which can be opened at the top; *e*, iron channels through which the air enters; *f*, hollow tube covered with mica for observing the flame; *g*, plate which causes the air coming through the channel *e* to be heated by forcing it to come close to the fire bars.

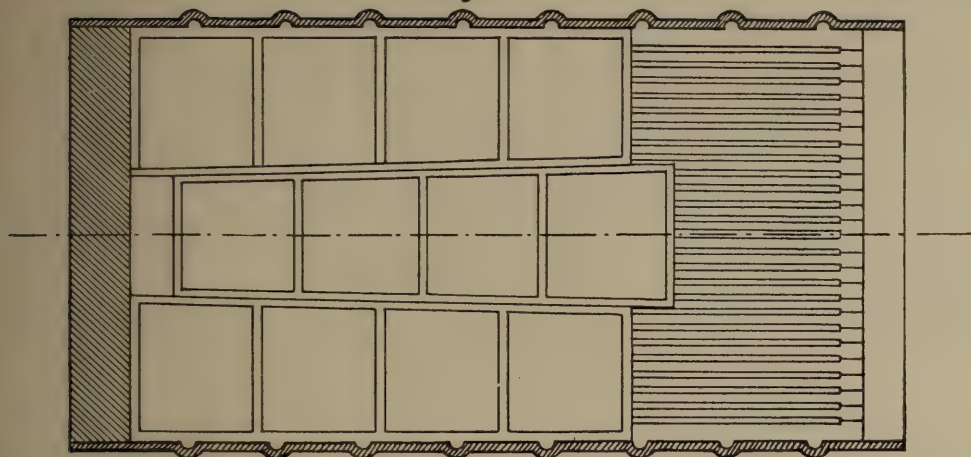
Fig. 3.

Fig. 3 shows how the fire bars are covered with cast-iron plates. The middle plate projects about 7.89 inches, in order to allow the entrance of air in the neighborhood of the fire bridge. Experience has shown the usefulness of this arrangement.

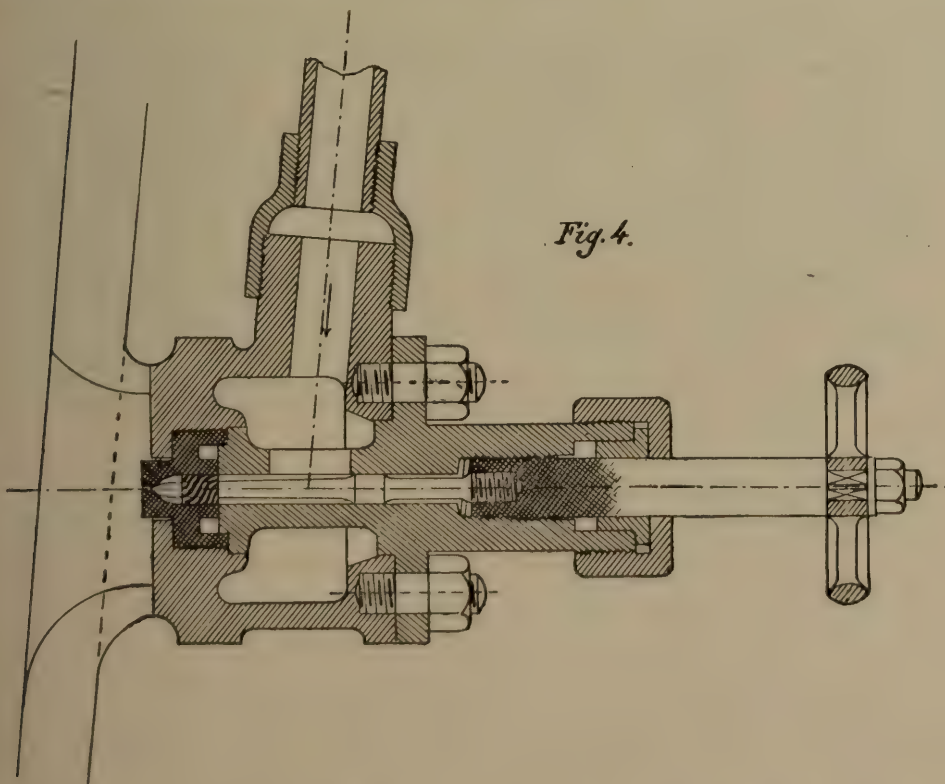
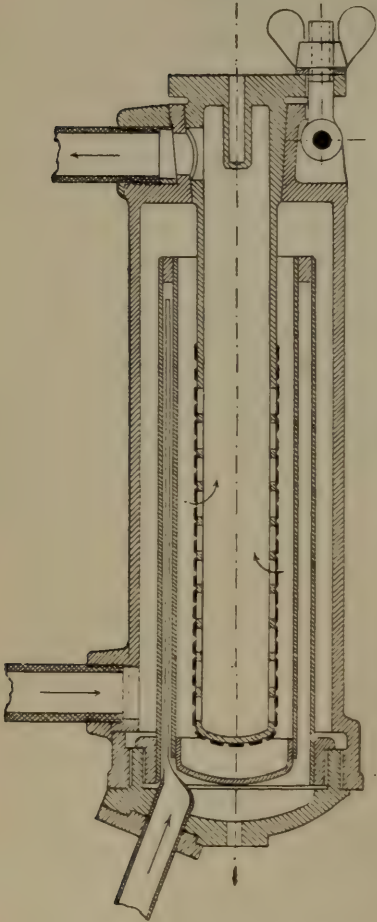
Fig. 4.

Fig. 4 shows a section of a burner. The opening has a diameter of 0.04 inch. The needle, which can be moved, has near its end a thread which gives the outflowing *astatki* a rotating motion.

Fig. 5 is the astatki filter, and at the same time a heater. The astatki is pressed in and comes into the central tube, which has many openings and which is surrounded by a copper-gauze tube. These two tubes can be taken out when cleaning is needed.

Fig. 5



The double cylindrical wall which runs around the center body gets the steam for heating the astatki, and is connected with the exhaust steam pipe of the astatki pump.

The astatki is used as follows: The pump draws it from one of the tanks and through a heater, which is like that described, but without copper gauze. It passes then through the pumps and is then pressed through the filter heater to the burners.

On the other side, where the astatki leaves the pump, there is an air box in order to obtain a regular pressure.

The pressure side of the astatki pipe is connected through a valve with a spring with the drawing slide, so that the pressure of the pipe leading to the burner can be regulated, for which a meter is placed on the steam pipe which heats the astatki.

In order to fire with astatki the following is done: First, steam is raised with coal or wood, in order to run the astatki pump.

This can be done with or without the iron plates placed on the grates.

When steam is raised, then the fires are drawn out, the iron plates, if not yet put in, are placed with the center plate as indicated, the dampers are placed before the ash plates, the levers of the air boxes opened, the astatki pump started, and the burners opened and lighted.

All grates in the fire doors, dampers, and around the burners to be kept open. Opening the doors a little gives good results.

The astatki is stored in the side bunkers. It is brought in place with the above-mentioned duplex steam astatki pump, which also may pump out the tanks in case of fire. It can also be used as a bilge pump in case the astatki may have leaked out in the boiler room. This is the same pump which brings the astatki to the burners.

Within about one hour firing with coal can be replaced with firing with astatki, and during that period firing with one furnace can be continued. In this case the speed of the ship was 7.5 knots. Maximum speed about 11 knots, with about 520 I. H. P. Each ship carries

about 78 tons of coal, divided between two side and one cross bunker. The side bunkers are used for storing astatki.

The Dutch East India Company also made modifications as follows in the Korting system, as a result of its experiments:

This powerful concern has a very large fleet in the Dutch East Indies, and in view of the abundance of astatki there (Sumatra) a series of trials were made by them which ended in complete success.

The developments in this system of astatki burning are practically made in three stages.

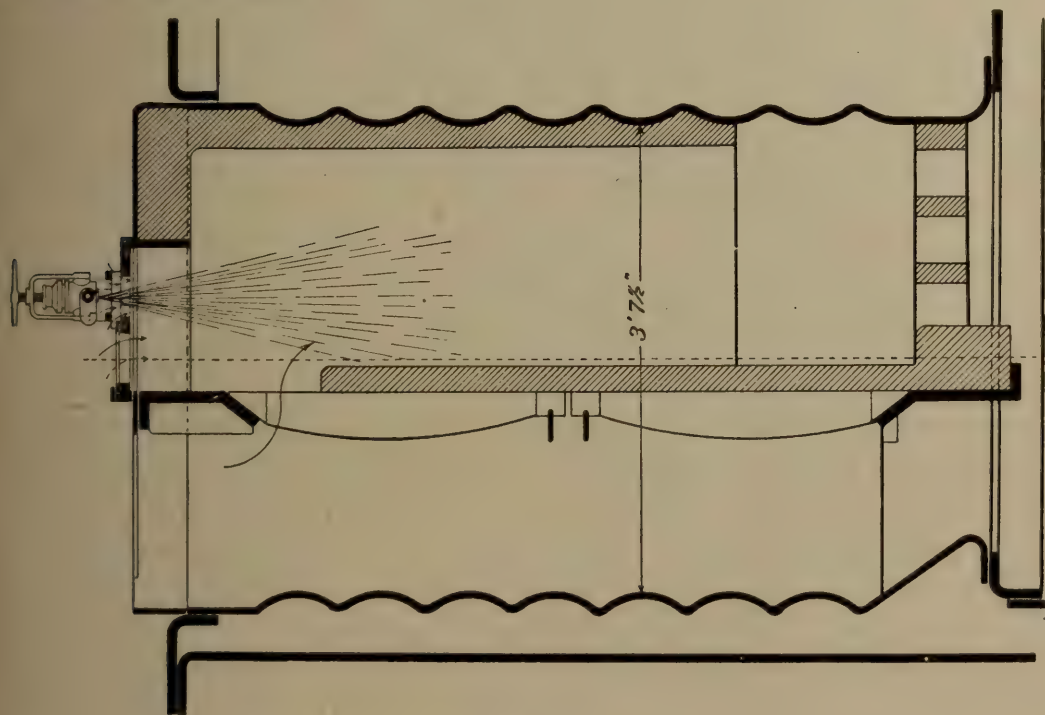


Fig. 6.

I. One of the three furnaces of a boiler for *S. S. Brouwer* was built up as shown in fig. 6, according to plans furnished by Korting, of Hanover. The grates are almost entirely covered by brick, only forward is an opening through which the air enters. It can also enter through an opening covered by a shutter in the furnace door.

The top of the furnace is covered with brick, in order to prevent the flames from cooling off, and on the bridge is also a brick wall with openings.

Two Korting burners are placed in the fire door.

The results were not bad, but the smoke was very heavy, and the fire-door became red hot.

It was then tried to admit air in several other places in the center and aft of the grates, even aft of the bridge. Also the grates were covered entirely with round bricks, in order to get a great many smooth openings; but the smoke remained very heavy. That this was not caused by lack of air was evident, because the smoke remained the same with everything open, as it was with the grates covered for three-fourths of the total surface.

If this incomplete combustion was not caused by the quantity of air, it could be attributed only to a too low temperature at which the combination (air and astatki) took place.

The engineer in charge, Mr. Kloos, then tried to heat the air before it came in contact with the astatki. He placed a plate in the furnace by which the air was brought to the near end of the astatki. On the grates he placed another plate which covered everything aft, which left an opening forward. This plate became red hot by the flames, the air passing underneath it became warm, and then came in contact with the astatki.

The result exceeded expectations. At the top of the furnace no smoke could be seen. As a consequence, a system has been built up based on the same principle.

II. Fig. 7 shows the furnace as it is built now. In the place of fire bars a cast-iron floor is laid, smooth on the top, but provided with ribs underneath. Therefore, the surface taking up the heat is much smaller than that which emits it, and so the temperature of the iron floor is kept low. Burning of this floor is, therefore, prevented.

In practice, this floor does not even become dark red. The opening in the floor forward is made small, in order to prevent the air from entering the furnace with great velocity, so that a good combination with the astatki is obtained.

The plate in the ash pit under the floor (see above) has been given a curved form, in order to gather the astatki continually leaking out from the fire. As this plate has an inclined position, this astatki will drop outside the boiler. The fire door is closed by a thick brick with two openings, corresponding with the openings for the burners in the fire door.

During a five hours' trial in the open sea on March 30, 1898, absolutely no work had to be done in the fire room. The temperature of the astatki in the pumps was kept at 194° to 212° F., and the pressure at 40 pounds. The combustion in each furnace was 309 pounds per hour, which furnished enough steam to keep up the required speed.

The smoke was very thin, sometimes hardly visible.

At the end of the trial it was desired to make more steam, and therefore the pressure was brought up to 50 pounds.

More steam was gotten, but also more smoke, suddenly caused by too little air.

The opening in the cast-iron plate or floor was fixed at 2.5 inches at the preliminary trial. For ordinary service this would be enough, but when a higher combustion was desired the opening would be too small. It could not be enlarged during this trial.

Before leaving for Java, the ship, however, got other plates, in which the opening was larger, and was placed more forward, so that the ribs would be made longer.

These systems have the great advantage of not requiring steam vaporization.

The French navy, which has a number of its vessels fitted for carrying oil (No. XIX, p. 231) as an auxiliary to coal, has been carrying out some experiments with solidified petroleum on board torpedo boat No. 180. These trials have been in two parts. During the first, ordinary coal and solidified petroleum were burned together, with fair results as to rapid steam generation, but very shortly after the fires were lighted the spaces between the grate bars became choked, showing that a rearrangement of the latter would be imperative.

The second series of tests were effected with the use of the solidified petroleum alone. Great difficulty was experienced in firing, and the ordinary firing gear could not be used. The funnels carried a "torch" of flame nearly two meters high, and the boat was enveloped in a dense cloud of smoke.

The grate bars were badly clogged and ten of them were burnt out. The furnaces gave out an odor of petroleum that was very disagreeable to the fire-room force. In spite of these very unfavorable results, further tests are to be made of the apparatus. The French navy has always been partial to petroleum briquettes for reserve fuel, and they are being manufactured in great quantity at St. Etienne and other points in France.

Germany continues to make provision for the carrying of liquid fuel, and the recently launched cruiser, *Prinz Adalbert*, has storage for 200 tons of tar oil in addition to her bunker capacity for 1,500 tons of coal. Since the grounding accident to the battleship *Kaiser Friederich III* (see p. 280, No. XX) there has been question as to the advisability of carrying liquid fuel in the double bottoms of ships, but the German authorities have found no better place in which to carry liquid fuel, each of their battleships having in the neighborhood of 100 tons of "masut" (tar oil), or, more recently, Texas oil. In the future, to obviate such disasters, it has been ordered that oil tanks in double bottoms should only be filled to 75 per cent of their full capacity.

In this manner, in case of striking a rock or other obstacle, the bottom will only be indented to the extent of forcing the air out of the upper part of the tank. A heavier blow would break the plating, and the oil would not be forced up into the ship, but would simply leak out of the tank.

The following account of the experiences of the German steamship *Tanglin* with liquid fuel, reprinted from the *Marine Review* of January 23, 1902, is of interest:

PRACTICAL TEST OF FUEL OIL.

Particulars are published in the German papers of results obtained in a practical test of the value of fuel oil in the generation of steam on an ocean steamship,

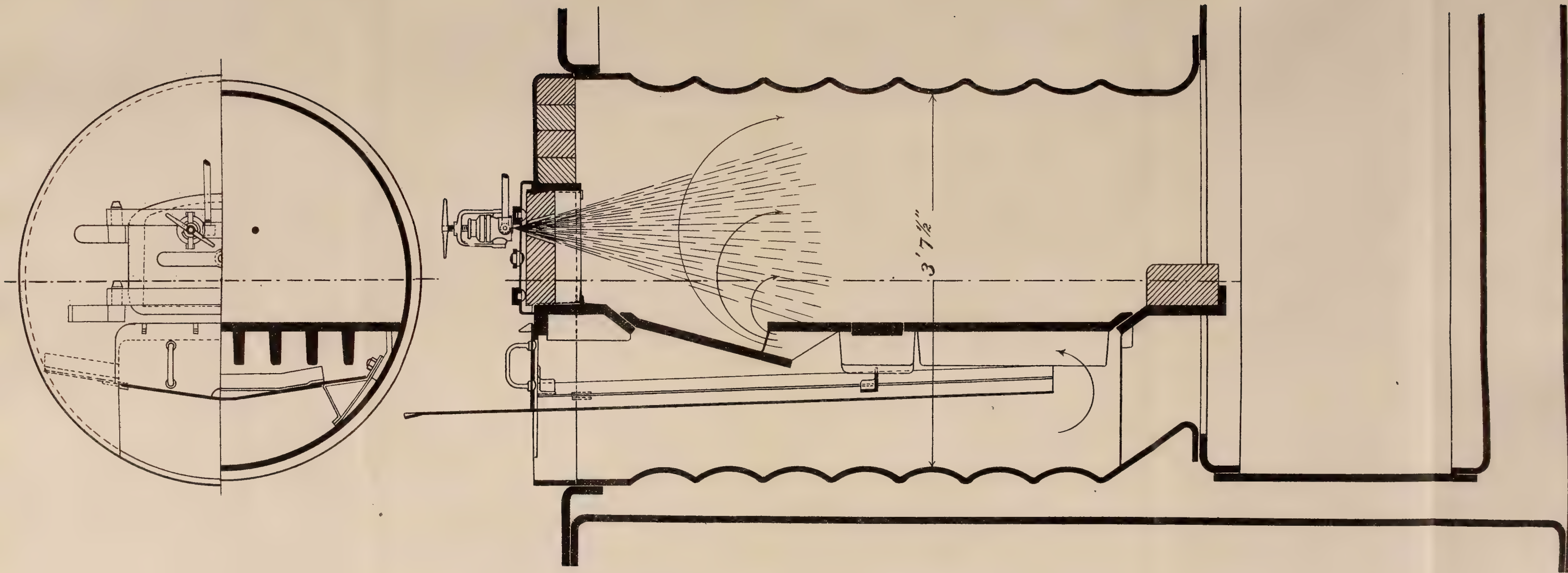
recently made in the case of the North German Lloyd vessel *Tanglin* on a voyage from Singapore to Sydney, a distance of nearly 5,500 miles. The *Tanglin* was chartered to convey to Kerguelen Island the dogs, equipment, and coals for the German Antarctic expedition. She is a steamship of about 2,000 tons capacity, built last year for the North German Lloyd, by Workman, Clark & Co., Belfast. She is intended for the East Indian trade and was fitted with apparatus for burning oil and saving labor in the stokehold. Her ordinary bunkers are used for the storage of oil, all apertures being closed and made water-tight, and the oil is pumped in from craft lying alongside. The oil used by the *Tanglin* came from Borneo and was taken on board at Singapore. By the method adopted on board this boat the oil is converted into spray and blown on the grates by means of injection tubes and nozzles pierced with fine holes. The service of only one man is required in feeding the fires, and the supply of oil and steam pressure are always directed to the required point by means of special valves. The *Tanglin's* bunkers are so constructed that they can be used for either coal or oil.

Compared with the old system of coal stoking, the following results were arrived at: The weight of each day's supply of fuel was much less, and a great saving of labor was effected, inasmuch as only one man per watch was required instead of five. The *Tanglin* took 350 tons of oil on board for her voyage (her capacity of coal is 300 tons), and with a consumption of 13 tons per day an average speed of $11\frac{1}{2}$ knots per hour was attained. This means an increase in the speed amounting to a knot per hour. The most disagreeable task connected with coal stoking is cleaning out the furnaces. When oil is used, there is no cleaning to be done.

The chief engineer on board the *Tanglin* expressed his entire satisfaction with the result obtained. He is of opinion that liquid fuel will be extensively used on board great ocean steamships, and in his report to the directors of the Lloyd company he strongly advocates the adoption of the new method. The *Tanglin* used coal on her outward voyage as far as Singapore, and after shipping oil there she proceeded to Bangkok, consuming 13 tons of oil daily, against 18 tons of English and 20 tons of Japanese coal. The report adds that the oil gives off no odor and that the heat in the engine room was quite insignificant, while the required pressure of steam was maintained with ease. As regards the cost, the oil was put on board at Singapore at 30s. a ton, and the whole quantity—350 tons—was got into the bunkers in three-quarters of an hour. The cost of coal in the same port, brought alongside, was 25s. a ton.

The mere comparison of the daily expenditure for fuel, namely, 20 tons of coal at 25s., equal £25, against 13 tons of oil at 30s., equal £19 10s., a saving of £5 10s. per day in favor of oil fuel, does not represent the whole gain to the shipowner. There is the extra freight that he may earn as represented by the difference between 13 tons and 20 tons dead weight of daily consumption, which on a twenty days' run would be equal to 140 tons. There is also the extra measurement cargo which he may carry by stowing the fuel oil in the ballast tanks and peaks, and there is the saving of firemen and the time in bunkering ports. It is evident that 350 tons of oil bunkers taken on board in three-quarters of an hour can find no near comparison in the case of any recorded instance of coal bunkering, and the cleanliness of taking on board liquid fuel in comparison with dirtying the decks and passenger accommodation due to coal bunkering is also an appreciable financial asset upon routes where passenger competition is at all keen. The extra speed of the *Tanglin* when using oil fuel illustrates the experience that has been reported in respect to other vessels, namely, that boilers which are hard to steam with coal become quite easy to steam with oil on account of the greater intensity of the heat generated by the new fuel.

In Germany the Durr system of liquid fuel firing has recently been much improved and is now being successfully tested. This system



APPARATUS FOR BURNING LIQUID FUEL ON BOARD THE S. S. "BROUWER."



has already been described in No. XVIII, page 236. Fig. 8 shows the improved form of gasefying apparatus. An essential improvement over the former type consists in having a cleaning arrangement so that the small aperture admitting the oil to be evaporated to gas may be clean — insure a constant supply of ignited gas to the furnace. Texas oil is used, which, after being freed from sulphur, is noncombustible under 200° F. There is absolutely no smoke whatever with this system and Texas oil. In the first type there was con-

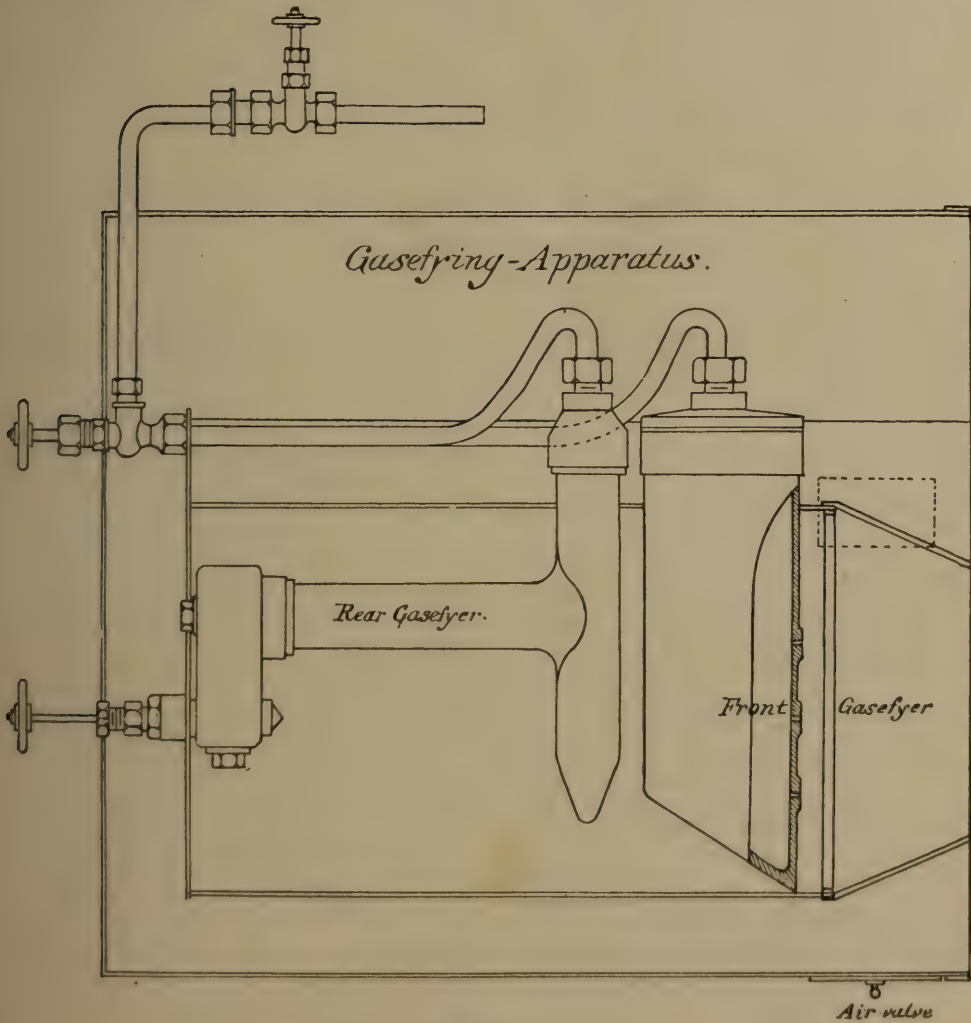


FIG. 8.

siderable roaring noise made by the flames of burning gas. This has been reduced to a great extent, though is still quite apparent.

The appended paper on liquid fuel, read before the British Institute of Naval Architects on March 20 by Sir Fortescue Flannery, one of the very best authorities on this subject, so completely covers the ground of recent progress that further statement other than the preceding supplementary notes is unnecessary. Of course Sir Fortescue Flannery is an enthusiast in favor of oil, and so touches but lightly on the difficulties that have arisen so often in experiments with oil for naval use—dense smoke, loud, roaring noises in the furnaces, smell,

occasional flaming at funnels, and the danger of racking strains to the boilers or of explosive gases being formed in the furnace when, by sulphur or water in the oil, the burners are suddenly extinguished. Mention need not be made of the wasteful use of steam vaporization, for this is already obviated by a number of systems, and also the other difficulties are being attacked and seem to be in a fair way toward being eliminated.

In the discussion that followed the reading of this paper several valuable and expert opinions were given in regard to the difficulties and advantages of the system of oil firing. In regard to the question of water in the oil, it was pointed out that the residue burned was the product of distillation at 400° F., and that therefore with ordinary care the oil should contain no water. It was also noted that boilers in the merchant marine and in naval vessels were so different that it was difficult to compare them. The makers of mercantile boilers are not confined by the same restrictions, and the boilers can be made roomy enough for full power as a regular thing. This has an important bearing upon liquid fuel. In mercantile vessels the ratio of $2\frac{1}{2}$ pounds of fuel per cubic foot of combustion space per hour might be taken; in H. M. S. *Surly's* boilers they burnt 12 pounds per cubic foot of space.

For perfect combustion it was necessary to have the required quantity of air, and in regard to this there was a point to be observed as to where the air should be admitted. It was quite possible to get overheating in the uptake and retarded combustion if air were admitted improperly. With a sufficiently large furnace it was thought combustion with oil fuel should come very near perfection. Again, it was necessary to have a certain amount of brickwork, and that could be got in a mercantile boiler easily, but not so easily in a naval boiler. It was claimed that with oil fuel the stoker could be abolished. In the navy the stoker was a good man for many purposes. It should be remembered that the merchant steamer, once clear of port, proceeds at a uniform speed throughout the voyage. In the man-of-war there was often a constant variation of speed, changes being made at intervals of less than three minutes, and this necessitated constant attention to the valves which controlled the oil supply to the furnace.

There were varying opinions in regard to the relative efficiencies of coal and oil. Sir Fortescue Flannery claims that 2 tons of oil is equivalent to 3 tons of coal, or 36 cubic feet of oil is equal to 67 cubic feet of coal, as usually stored in ships' bunkers, which would increase the range of action of a war ship by 50 per cent for the bunker space allotted, or nearly 90 per cent upon the bunker space. The British Admiralty considered the fuel value of oil was not 50 per cent greater than coal, but only a possible 33 per cent. In reply to this the author stated that the result of six years' experience with merchant vessels had shown 16 tons of oil to give the same horsepower as 25

tons of coal. On larger vessels 29 to 30 tons of oil replaced 43 tons of coal. Experience with other vessels had been still more favorable, and in one case the ratio of coal to oil was 3 to 2. Recent exhaustive comparative tests of Texas oil and coal made in a land boiler by Professor Denton, of Stevens Institute of Technology, Hoboken, N. J., have given the following:

Evaporation per pound of coal from and at $212^{\circ}=9.17$ pounds.

Evaporation per pound of oil from and at $212^{\circ}=15.1$ pounds.

Or 1,362 pounds of oil is equivalent to 2,240 pounds of coal, which gives as a ratio of efficiency of oil to coal of 1.65. These tests were conducted with great care and under the best possible conditions.

ON LIQUID FUEL FOR SHIPS.

[By Sir FORTESCUE FLANNERY, M. P. (member). Read at the spring meetings of the forty-third session of the Institution of Naval Architects, March 20, 1902.]

The subject of this paper is not in any sense new. The use of liquid fuel has been known for many years to be mechanically possible, and the transactions of this institution contain many important references to the question. The late Admiral Selwyn was an enthusiastic advocate and an eloquent exponent of the special advantages of liquid fuel for vessels of war.

The use of this fuel on the Caspian Sea began in 1870, and is quite the recognized custom in about 200 vessels. The fact that the vessels navigate in fresh water, and can therefore afford an unlimited supply of steam for pulverizing the fuel without any risk of undue incrustation to their boilers, is an important factor. The Russian law, however, prohibiting the exportation of liquid fuel has been the dominant factor in the confinement of the use of liquid fuel at sea to the Caspian for at least a generation after its successful use there has been demonstrated.

While the advantages of liquid fuel and the possibility of its successful mechanical use have been generally admitted, little or no progress in its application had been made outside the Russian inland sea just referred to, and the reason of this stagnation has been mainly of a commercial character. The supply of fuel outside Russia has been but nominal, and no general application was possible, unless both war and mercantile vessels could be assured of continuous supply from year to year, and unless that supply were as regularly accessible at as frequent and convenient oiling stations throughout the world as already exist in the case of coal fuel, and at a cost proportionately as low. Such a condition of things never became possible until the recent discovery of large supplies of oil suitable for fuel, first in Borneo and Burma, and quite recently in Texas and California. It is to be regretted that the only one of these sources of supply that lies in British territory is that of Burma.

The whole aspect of the question, whether regarded by the Admiralty, the ship-owner, or the naval architect, has been changed by the assurance of continuous supplies of liquid fuel, and it becomes necessary to treat the question not only as of practical importance, but of urgency to those responsible for the highest efficiency of fighting and carrying ships. The British Admiralty has determined to exhaustively test the use of this newly resuscitated means of evaporation, and the reference to the question by the first lord in his recent memorandum is a clear indication of progressive policy—a policy which is understood to extend to trials not only in destroyers, but also in three cruisers and one battleship. The Italian Admiralty have been pursuing the question for some years, even before large supplies were assured. The German Admiralty have used liquid fuel on the China station for many months in

lieu of coal for auxiliary purposes on board ship. The Hamburg-American Steamship Company have fitted four steamers for liquid fuel, and the North German Lloyd two vessels. The Dutch navy have fitted liquid-fuel apparatus in conjunction with coal to two destroyers, and Dutch mail and cargo steamers in the Far East have the new liquid fuel in regular use. Danish shipowners have ordered the building in Germany of two steamers to burn liquid fuel, and some twenty vessels under the British flag are now running regularly under liquid fuel, while at least a dozen are building with suitable fuel apparatus included in their design.

SUPPLY.

Storage and supply of this fuel are in regular currency, or in course of arrangement, at the following ports: London, Singapore, Hongkong, Madras, Colombo, Suez, Hamburg, Port Arthur, Texas, Rangoon, Calcutta, Bombay, Alexandria, Bangkok, Saigon, Penang, Batavia, Surabaya, Amoy, Swatow, Fuchow, Shanghai, Hankow, Sydney, Melbourne, Adelaide, Zanzibar, Mombassa, Yokohama, Kobe, and Nagasaki, and storage arrangements are projected in South African and South American ports.

It may be expected that the supply to these stations will be drawn as regards the ports east of the Suez Canal from Borneo and Rangoon, and as regards those west of the canal and in South America from the Texas fields, South African stations being neutral as regards the heavy charges of the Suez Canal, and therefore likely to draw their supply from Borneo or Texas with equal economy. The South American stations will no doubt be supplied from the Texas and California fields.

CHEMICAL COMPOSITION.

It is not within the scope of this paper to exhaustively discuss the refining and chemical constituents of the fuel, but a general statement of what is meant by liquid fuel is necessary.

The product as it issues from the wells may be roughly said to be divisible into five principal sections, i. e., spirit (benzine or naphtha), kerosene or petroleum lamp oil, solar oil, astatki or residuum, and water. The spirit and the lamp and solar oils are too valuable commercially to be used as fuel in competition with coal; but the residuum, a thick, treacle-like, sluggish liquid, is, if sufficiently separated from water and other impurities, very suitable for fuel, consisting, as it does, of the following chemical elements: Carbon, 88 per cent; hydrogen, $10\frac{3}{4}$ per cent; oxygen, $1\frac{1}{4}$ per cent.

The two impurities whose presence is most inimical to steam generation are water and sulphur. Water puts out the flame and causes an inrush of cold air very injurious to the boiler, and sulphur, if free—that is, not chemically combined with the oil—is injurious to both copper and steel. These impurities are now, however, of rare occurrence, and although, as will be seen later on, mechanical means of separation from water are necessary on board ship, this necessity arises rather from the admixture of ballast water than from water not taken out of the oil in the process of refining.

The question of safety and flash point is of extreme practical importance. The British Admiralty have hitherto required a flash point of 270° F., Lloyd's Register has required a flash point of 200° F., while the German authorities have accepted as safe a flash point of 150° F. Fuel of the lower flash point has been in constant use for four years in British and Dutch mercantile vessels with complete immunity from accident. It is not desirable to fix a flash point higher than is really necessary for safety, because high flash points are obtained by refining the volatile elements out of the liquid to such an extent as to leave a thick and sluggish residuum, requiring large power to pulverizé it into spray before ignition in the furnace, and necessarily more expensive by reason of the additional refining process.

The problem that confronts every designer of a war ship is the combination of the greatest speed, armament and ammunition supply, protection, and range of action in the smallest and least expensive hull, and any reduction of weight and stowage room of any of the necessary elements of any of these qualities is a saving which acts and reacts favorably upon the problem in a manner familiar to us all. The practical figures of comparison between coal and oil fuel realized in recent practice are that 2 tons' weight of oil are equivalent to 3 tons' weight of coal and 36 cubic feet of oil are equivalent to 67 cubic feet of coal as usually stored in a ship's bunkers; that is to say, if the change of fuel be effected in an existing war vessel, or applied to any design without changing any other of the data than those affecting the range of action, the range of action is increased by 50 per cent upon the bunker weight allotted and nearly 90 per cent upon the bunker space allotted.

The coal protection for cruisers, whatever its real advantages—a matter upon which different opinions exist—would disappear with the use of liquid fuel, because it would be for the most part stowed below the water line, if not wholly in the double bottom. The double bottom and other spaces, quite useless except for water stowage, would be capable of storing liquid fuel, and the space now occupied by coal bunkers would be available for other uses.

The ship's complement would be reduced by the almost complete abolition of the stoker element and the substitution of a limited number of men of the leading stoker class to attend to the fuel burners under the direction of the engineers, and the space of stokers' accommodation, the weight of their stores, together with the expense of their maintenance, would be saved. The number of lives at risk, and of men to be recruited and trained over a long series of years, would be reduced, without reducing the maneuvering or offensive or defensive power of vessels of any class in the fleet.

Rebunkering at sea—so anxious a problem with coal—would be made easy, there being no difficulty in pumping from a storeship to a war ship in mid ocean in ordinary weather. Three hundred tons an hour is quite a common rate of delivery in the discharge of a tank steamer's cargo under ordinary conditions of pumping.

The many parts of the boiler fronts and stokehold plates, now so quickly corroded by the process of damping ashes before getting them overboard, would be preserved by the action of the oil fuel, and the same remark applies to the bunker plating, which now so quickly perishes by corrosion in way of the coal storage.

Liquid fuel, if burned in suitable furnaces with reasonable skill and experience on the part of the men in charge, is smokeless. It is easy to produce smoke with it, but this is evidence of its being forced in combustion or of the detail arrangements of the furnace being out of proper proportion to each other. In regard to smokelessness, it is, when used under conditions customary in the merchant service, not inferior to Welsh coal, and superior to any other coal ordinarily in use.

The cost of fuel in the East is less than that of Welsh coal when the cost of transport and Suez Canal dues are added to the original price of the coal as delivered in a Welsh port.

The evaporative duty required from the boilers of destroyers is greater than that required for boilers of any other type, and, while it is possible to burn enough liquid fuel to produce the required duty in boilers hitherto using coal at natural draft, or even coal at moderate forced draft, difficulty has been found in burning enough oil fuel in boilers of the destroyer type to produce the same duty as that realized under coal at great air pressure. The question of economy of fuel in destroyers when at full power is of comparatively little importance, but the production of the maximum power is essential; and further experiments now in process will probably solve the difficulty as it has been solved in locomotive practice on the Great Eastern Railway by the skill and enterprise of Mr. Holden.

Messrs. Yarrow have obtained some highly encouraging results in two torpedo boats built by them for the Dutch Government. Their process is to obtain the maximum speed with coal under all usual conditions of forced draft, and then to inject liquid fuel into the furnace above the coal, thus securing additional boiler duty while leaving the whole of the grate surface available for coal combustion. The result was to increase the maximum speed of the vessel by over 1 knot per hour. Messrs. Thornycroft have recently made experiments, and have obtained the high evaporative duty of 18.95 pounds of water per pound of oil fuel.

The extra rapidity of raising steam with liquid fuel is undoubted, and this is a feature upon which much stress has been laid in recent naval debates. So far as experience has shown there is no deterioration of liquid fuel, however long it is stored before use.

COMPARATIVE ADVANTAGES AND DISADVANTAGES FOR MERCANTILE SHIPS.

The conditions which fuel most fulfill in the case of a mercantile vessel differ only in some respects from the conditions applying to a war vessel, the chief difference being that of cost. The question of direct cost is of little importance in a war vessel, provided the advantages above named are really secured in practice, but in a commercial vessel the direct cost of fuel, although here also necessarily merged in other questions, is of the first importance. While the supply of liquid fuel was confined to the Eastern Hemisphere, it seemed hopeless to expect its successful commercial competition with coal west of the Suez Canal, because of the light freight and transport charges, although for the converse reason it seemed easy for oil to beat coal east of the Suez Canal, and for some time Suez appeared to be the nearest economical station for British ships. The discovery of oil in Texas, however, and the splendid enterprise and foresight of Sir Marcus Samuel in organizing a fleet of vessels for its transport and tanks for its storage have changed the situation, and there appears no reason to doubt that ports in the Western Hemisphere can be supplied with oil from Texas at a cost not proportionally exceeding that of coal.

The saving of stokers is considerable, although the complement should not be reduced below that necessary to assist the ship's engineers in overhauling or in case of emergency. In some instances a stoker's and trimmer's crew of 32 is now represented by a fireman's crew of 8 hands, whose duty, however, is mainly cleaning and helping the engineers with their greasing. The Hamburg-American S. S. *Ferdinand Laeisz* was recently reported to have discharged her stokers at Singapore in consequence of successful experience in using liquid fuel. Some of the great Atlantic liners experience a difficulty in maintaining their full-power speed as compared with the performances when the ships were new. This is not due to any deterioration in the boilers or machinery or quality of the coal; it is due to a difficulty in getting the trimming and stoking done to the fullest capacity of the boilers, and in the case of these vessels, while the saving of stokers' wages and provisions and the substitution of additional passenger accommodation would be great commercial gain, the advantage of increasing the power and speed and rendering them more uniform would be of even greater importance.

In the case of medium-sized vessels working with natural draft, the advantages of uniform steaming, irrespective of wind and ventilation, and of large reserve of steaming power are the same for liquid fuel as for every other system of forced draft.

The greatest commercial gain, however, is the increase of weight and space available for freight. Adopting the proportion of 3 tons coal as equal to 2 tons oil fuel we find a gain in weight of, say, 1,000 tons in the freight of a first-class Atlantic steamer, and a gain of nearly the whole of the bunker space, which, subject to drawbacks of nonstowage in the hot parts of the bunker space, would be available for measurement freight. Allowing for these, and assuming the storage of the whole of the fuel in the double bottom and peaks, there would be again approaching 100,000

cubic feet of measurement made available for freight in such a vessel. The gain from substituting the new fuel in vessels of less steam power proportionate to the size would be correspondingly reduced, but it may be fairly estimated for most ships that 25 per cent of the space now occupied by coal bunker storage could be utilized for cargo by the transfer of the fuel in a liquid form to the double bottom and other parts not now of any direct use.

The cleanliness of oiling instead of coaling passenger ships and the saving of detention at ports of call are obvious.

The provision of storage and pumping and ventilation arrangements and of the furnace gear are a disadvantage both as regards cost and weight, and in some ships trouble and expense has arisen from boiler leakage consequent upon the presence of water in the oil and the lack of experience of the engineers, but these difficulties are now disappearing, and latest developments are in the direction of simplicity and less first cost.

Oil fires do not require cleaning, thus avoiding a prolific source of lost speed in ordinary voyage routine.

OIL STORAGE ON BOARD SHIP.

As already indicated, parts of the vessel hitherto useless except for water ballast or fresh water are most suitable for oil bunkers, both because of the freeing of other spaces for cargo and because of the immediate adaptability of the water ballast structure for holding liquid fuel. Lloyd's Register have published a set of rules applicable to existing vessels, which, although containing some requirements which may not ultimately prove to be necessary, are yet not unreasonable in regard to a system that had at the time the rules were issued all the risk of novelty. Indeed, the acknowledgments of shipowners are due to the registry committee and its officers for the enlightened and progressive attitude they have adopted toward this new departure in British vessels. The same acknowledgments are due to the marine department of the board of trade, whose officers have recently been closely investigating the question in detail, and who are understood to have determined that with such safeguards as experience has shown to be necessary, there is no obstacle to the use of liquid fuel on passenger vessels. The penetrating qualities of refined petroleum, or lamp oil, are well known, and such oil will find its way through a riveted and calked joint quite tight against water under pressure. This percolating quality does not, however, apply to fuel oil, the greater viscosity of the latter making it at least as easy to hold as water. It is believed that a ballast tank top or shell plating joint in way of oil storage, which is sufficiently riveted for water ballast, may safely be regarded as sufficient for liquid fuel, subject to test to a head of pressure at least equal to the load water line, and subject to all the usual requirements of separate oil-pumping pipes and connections, drainage wells, dunnage, and sounding pipes.

Some additional water-tight subdivision in the double bottom is necessary in large vessels to provide against the scend of a half-empty oil tank, but in vessels of medium and small size it is believed the usual subdivision is enough.

Fig. 1 shows the storage of liquid fuel on board *S. S. Murex*. This vessel is a tank steamer with all her tanks adapted as cargo holds to carry general cargo in the alternative with refined oil, and her original construction did not contemplate liquid fuel. She was built by Messrs. Wm. Gray & Co., of West Hartlepool, and about two years ago she was placed in the hands of the Wallsend Slipway Company for conversion to liquid fuel burning. Her cargo tanks have no double bottom below them, as they extend to the skin of the ship, but there is a double bottom, *a* and *b*, below the engines and boilers, and cofferdams, *c* and *d*, at the fore and after ends of the cargo space, the propelling machinery being aft. These spaces, along with the fore and after peaks, *e* and *f*, have been utilized for storing the liquid fuel. The settling or service tanks, *g* and *h*, have been built into the vessel at the height of the

'tween decks, and the process of receiving, storing, and feeding the oil to the furnace mouths is as follows: The flange J is coupled up to the store pipe, the oil passes along the receiving pipes K, K, K, K, and, by means of controlling valves, is directed into the fuel tanks, *a, b, c, d, e* and *f*. From the fuel tanks it is lifted by pumps, and delivered to the settling tanks, *g* and *h*. Each of these tanks is fitted with a steam coil for the purpose of slightly raising the temperature of the oil and facilitating the separation of any water it may contain from the previous use of the fuel tanks for water ballast. Each settling tank is proportioned to contain twelve hours' supply for the whole of the furnaces, and after twelve hours allowed for settling, the water is drawn off the lower part of the tank, where it settles by reason of its greater specific gravity, and the connections opened with the furnaces, while for the next succeeding twelve hours the other tanks perform similar functions of separating the oil from water.

The drainage wells required to prevent any accidental leakage getting into the ordinary bilge are shown at M M, with separate suction pipes and delivery pipes.

FURNACE ARRANGEMENTS.

These differ considerably, and it is certain that further advances toward perfection both as to economy and maximum effect will yet be made. As already explained, the fuel is too stiff to be burned except after disintegration, and this is effected either by pulverizing with steam, or by injecting the fuel under pressure, so that it breaks itself against an obstacle at the mouth of the furnace, or by vaporizing by heat before the furnace mouth is reached. Mr. Howden has a modified system by which the fuel is injected into the furnace at the same time as air under pressure, such air having been previously heated by the waste gases in the chimney. This system has been very successfully fitted to the North German Lloyd steamships *Tanglin* and *Packnam* by their builders, Messrs. Workman, Clark & Co.

All the vessels of the Caspian Sea have the direct steam pulverizing system, and some of them have been so running for twenty years.

As an example of the direct steam pulverizing type of furnace, fig. 2 shows the furnace gear of S. S. *Murex*, already referred to. This vessel arrived in the Thames last month, after a voyage of 11,800 miles from Singapore, via the Cape, pausing at Cape Town for four days, and the furnaces not being touched from the beginning to the end of the voyage. The consumption of coal in this vessel has averaged 25 tons. Her consumption of liquid fuel for the same indicated horsepower has averaged 16 tons. *a, a, a, a* are the steam pipes; *b, b, b, b* are the oil pipes; *c, c, c, c* the burners, which are hung on swivels, *d, d, d, d*, so as to be adjustable in position, and to be capable of swinging back to allow the opening of the fire doors, *e, e*, which are equally suitable for coal when the burner orifices, *f, f, f, f*, are closed by the pivoted slides. The brickwork is shown in fig. 3, at *n, n*, these being the pillars and arches against which the flame impinges in the first instance, and at *k, k, k, k*, these being the secondary bridges intended to baffle the flame and prevent its too direct impingement upon the stay nuts at the backs of the combustion chambers, the tube ends, the saddle-plate seams, and other parts liable to injury by the intense local heat generated by liquid fuel under steam impact.

Fig. 4 shows the steam burner of the Rusden Eeles type in section. It will be seen that the annular orifices, both for the admission of steam and oil, are adjustable while the apparatus is at work, and this appears to be an essential condition for exact adjustment to obtain the best results.

Fig. 5 shows the steam burner of the Holden type, which has the same facilities for adjustment, but the steam in this case passes through perforations in the outer ring *a, a*, and draws an additional supply of air into the furnace.

Specimens of these burners, and also of a simple nonadjustable burner made of gas piping, are laid on the table of the meeting.

During the development of the liquid-fuel system in the mercantile marine some doubt has been expressed by shipowners as to the possibility of quick reversion to coal if the supply of oil should fail, or if the cost of oil should suddenly be raised. To meet this difficulty, and to demonstrate the facility of interchange between the two fuels, the furnace of S. S. *Trocas* (fig. 6) was designed and fitted by the Wallsend Slipway Company, who have already fitted over fifty steamers to burn liquid fuel. In this case the fire bars are left in place and covered with a layer, about 8 inches mean thickness, of broken fire brick, *a*. Behind is the bridge, *b*, and above that again is a fire-brick protection, *c*, as already described, and a brick lining at the back of the combustion box, *d*.

To change from oil fuel to coal it is necessary to swing back the burners quite clear of the fire doors and lay them back against the boiler fronts, to open the fire doors and rake out all the broken fire brick, to lay the bars with coal and to ignite it either in the ordinary way or by means of the oil burners. These operations were demonstrated on *Trocas* at a sea trial in September last, and in twenty-eight minutes after steaming full speed under oil the vessel was steaming full speed under coal. On the whole, however, experience of long passages is against leaving the fire bars in the furnaces while working under oil, and the change from one fuel to the other can at the worst be effected in a few hours.

The consumption of steam for pulverizing is estimated at 0.2 pound per I. H. P. per hour. Large interchangeable evaporators are fitted as part of the liquid-fuel outfit, usually in three interchangeable sections, and when these evaporators have been worked steadily and successfully no ill effect whatever has shown itself upon the boilers. Two small burners in each furnace are preferable to one large burner, as being more easily adjustable and maintaining continuity of flame without interruption. The loud whirring noise which made the earlier steam burners so objectionable has been quite abolished in burners of recent manufacture.

The system fitted to the Hamburg-American S. S. *Ferdinand C. Laeisz* is that known as the Korting system, and does not involve the use of direct steam for pulverizing the fuel. After water separation in the manner already described, the oil is raised by a steam pump, and is heated to about 60° C. by a heater on the suction pipe. It is also filtered before reaching the pump valve. It then passes through the pump and is delivered to another heater, which raises its temperature to 90° C., and at this temperature, and after further filtration, and under a pressure of 30 pounds per square inch, it is injected into the furnaces. In the act of injection a spiral or centrifugal motion is given to the oil by a screwed needle, and this, added to the pressure from the pump and the softening effect upon the oil of heating to high temperature, causes the oil to spray and ignite. The fire bars are left out, and the furnaces are bricked right round, and air is admitted to the furnaces through perforated gratings, fitted with adjustable covers. This system has been so successful that the Hamburg-American Company have fitted four vessels upon it. Fig. 7 shows the furnace arrangements.

The Meyer system, fitted in the vessels of the Dutch Steam Packet Company, is also worked without steam jet, and largely depends upon the assistance to combustion of air heated previously to its meeting the liquid fuel. Figs. 8, 9, 10, and 11 show a furnace on the Meyer system. The furnace is prolonged by an annular extension, *B*. This extension is provided with spiral partitions, *C, C, C*, intended to give a whirling action to the air as it enters the furnace, the air as it passes through these spiral partitions being heated from the combustion inside the extension of the furnace proper. The injectors or burners for the oil are on the Korting system, already described. There are dampers, *E, E, E*, to control the admission of air. The Meyer system has now been in use for two years on several Dutch steamers, and with great success.

In the Roumanian service vessels have been running with liquid-fuel arrangements of a generally similar character.

It is believed that the present stage of advancement of this interesting question has now been generally described, and that the widespread attention and steady application of scientific research now being brought to bear upon so important a subject must lead to great developments in the near future.

BOILERS.

The past year has been characterized by a persistent discussion in naval engineering circles and in the technical press as to the relative merits of the various types of water-tube boilers in use in the navies of the world, and, to a much more limited extent, and more especially in England, to the relative merits of water-tube and cylindrical boilers. In most navies the cylindrical boiler seems to have been definitely and entirely abandoned, except in partial installation in large vessels in conjunction with water-tube boilers. This compromise arrangement has found much favor in Germany and has been used in Holland, and is to be tested by the British Admiralty. The numerous tactical and constructional advantages of the water-tube boiler over the cylindrical have been so often stated in previous issues of these notes, and are so thoroughly discussed in the appended article, "The water-tube boiler question in the German navy," that it would be superfluous to enumerate them here. There is a conservative element in Great Britain that has consistently upheld the cause of the cylindrical boiler for use in the British service, and these took much heart from the result of the *Hyacinth-Minerva* trials last summer, the Admiralty report of which is here appended. But as to actually settling the vexed question the results of these famous trials would appear to be unsatisfactory, for, though they showed that the Scotch boilers of the *Minerva* were superior to the *Hyacinth's* Bellevilles, the tests did not prove that the Scotch boiler is superior to other types of water-tube boilers, but simply seemed to confirm what the previous trials had shown—the special faults and deficiencies of the Belleville generator.

Of course a section of the English and the continental technical press, and world, did not accept, without much protest, these results, and made claim that much of the lack of success with Belleville boilers in the British service was due to unskillful care and operation by the personnel. That there may be ground for this claim is shown by more successful experiences with Bellevilles in other British vessels, and particularly in the trials of the new cruiser *Good Hope*, though it has by this become well known from sad experience that the performances of a vessel's boilers during trial trips, even of an extended nature, are no criterion of their subsequent behavior under service conditions.

France, Italy, and other naval powers have been using Bellevilles with satisfactory results during the past few years. While the Brit-



FIG. 5.

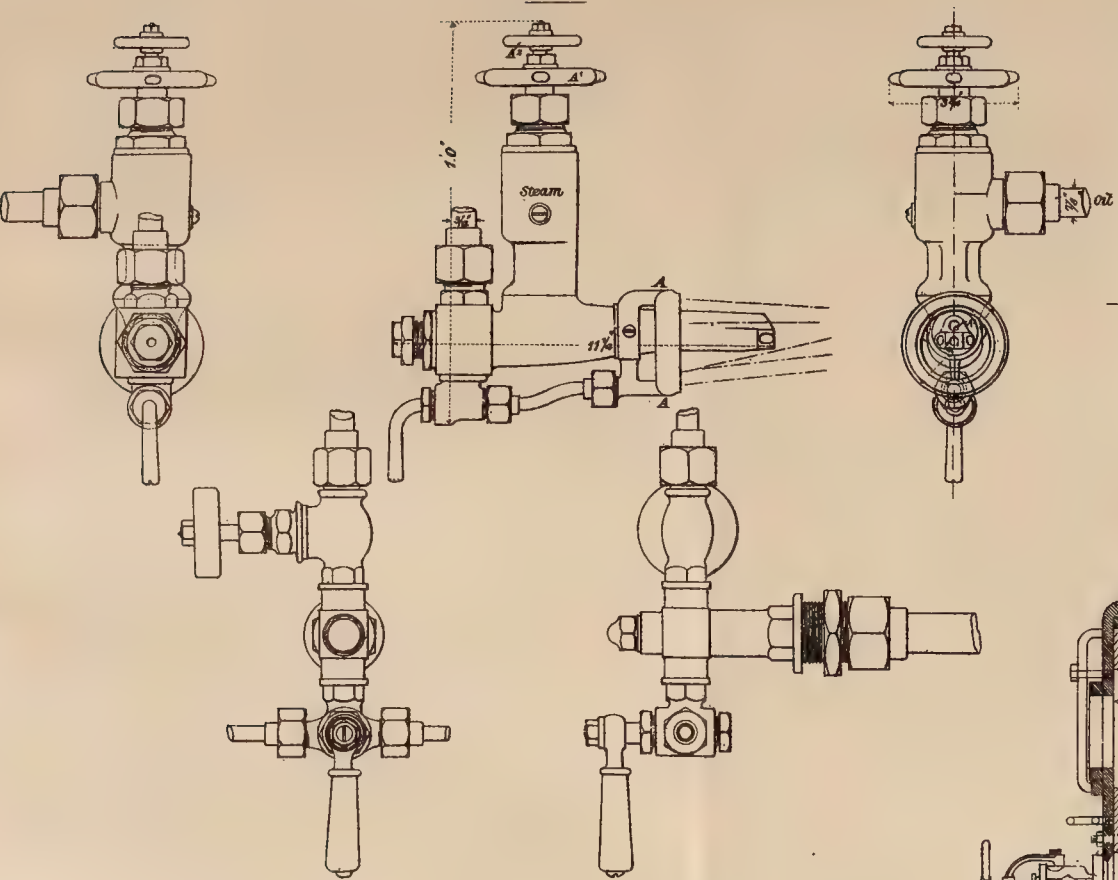


FIG. 6

ARRANGEMENT FOR OIL FUEL INSTALLATION
S. S. "TROCAS"

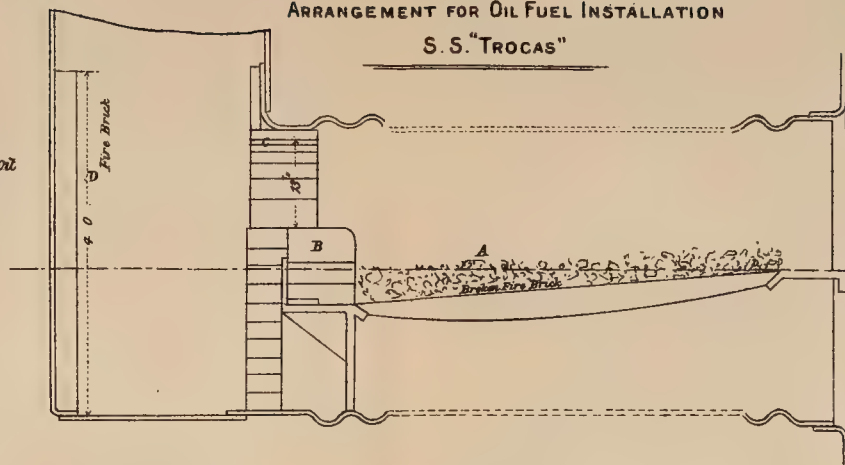


FIG. 8.



FIG. 9.

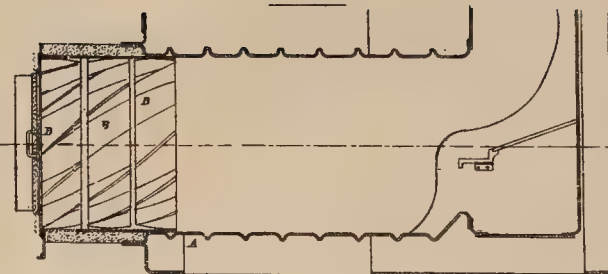


FIG. 7.

S. S. "FERDINAND LAEISZ."
BRICK WORK ARRANGEMENT OF DOUBLE ENDED BOILERS

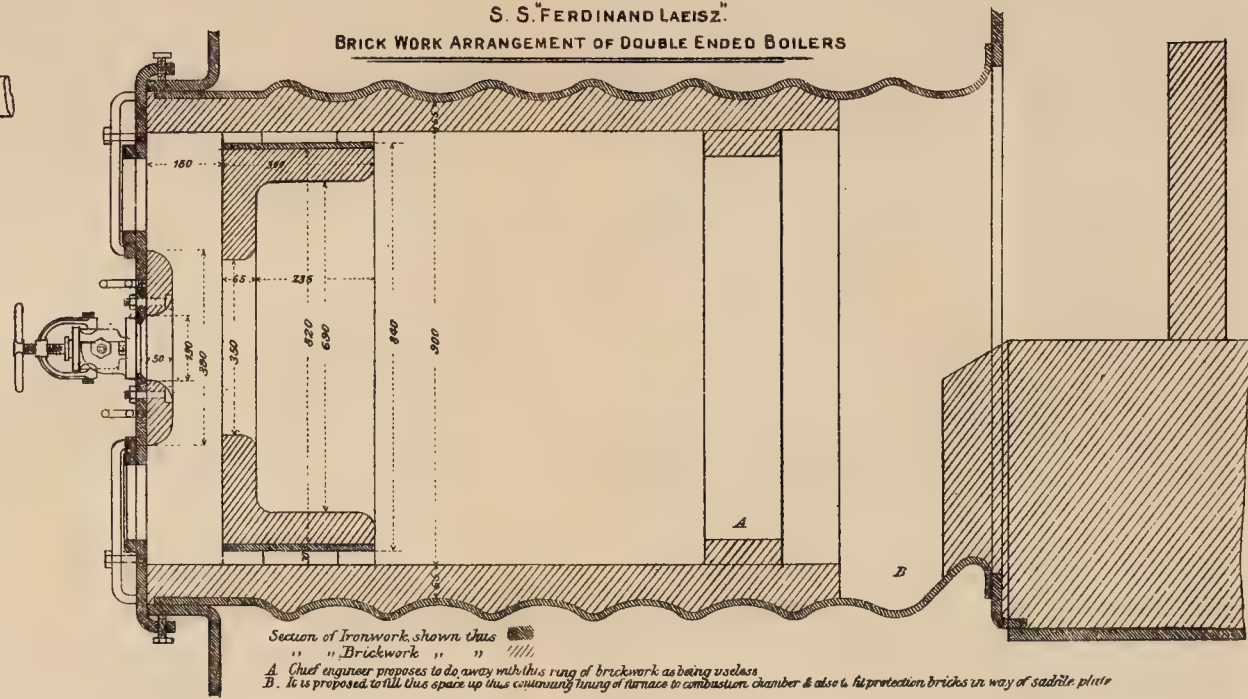


FIG. 10.

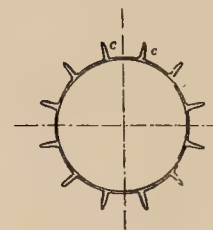
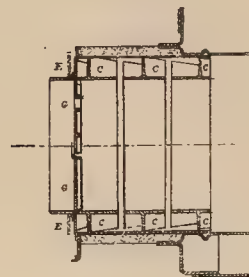


FIG. 11.





ish Admiralty were evidently justified, from the evidence before them, in condemning the exclusive, or even extended, use of the Belleville in their service, the engineering world in general feels that further exhaustive and long-lasting trials in competition with other water-tube boilers are essential before this system can be definitely condemned or placed in its proper position in a relative scale of merit of the various types. Germany and Italy have both engaged in such tests, accounts of which are given further along in these notes, and Great Britain is now, as befits the much greater size of her navy and her vital interest in such matters, about to carry out comparative trials upon the largest scale yet undertaken. The results of these trials will be watched with the very greatest interest, for the problem is still very indefinite, and the net results of investigation to date force us to the conclusion that though the water-tube boilers are superior, indeed essential, for our new vessels, yet each of the types in use has its own special defects and disadvantages. The problem would appear to be to find the boiler that has the least of such faults, or, better yet, to set about eliminating them in the present systems, or to discover an entirely new type that shall be free from them.

Water-tube boilers may be divided into two general classes—small tube and large tube. There has been controversy during the past year as to the relative merits of the two types for use in large vessels. In the small-tube type we have straight or bent tubes of an inch or so in diameter connecting water pockets at the bottom to a cylindrical steam drum at the top. This type has been almost universally used in all navies for launches, torpedo boats, destroyers, in many gun-boats, and in small cruisers, and in France, Germany, and some of the smaller navies to a greater or less extent in large vessels. The Yarrow, Thornycroft, Thornycroft-Schulz, Normand, Normand-Sigandy, Normand, and Guyot are the principal boilers of this type. The small-tube boiler first came to life about twenty-five years ago, owing to the demand then for higher speeds in torpedo boats. It is a very light boiler, which can be forced to an extent that other steam generators can not. It has practically enabled the modern torpedo-boat destroyers to attain their great speeds; but the life of the boiler is very short, the repairs required very great, and the skill in handling very considerable. These sacrifices are only what can be expected from a boiler designed to drive such frail craft as destroyers. Their average life is about two or three years in such racking service, but there are several new boats lying in the dockyard reserves that have had to have their boilers retubed in spite of only having recently been built, and never having steamed except on their trials. This is due to the decay that goes on inside the tube while the boilers are idle, and as the tubes are very thin they consequently can not afford to lose very much in thickness.

The general tendency lately has been toward the elimination of the small-tube boiler for large vessels, owing to the known difficulties in cleaning them and to dangers in operation. However, the French and German admiralities have by no means entirely abandoned them, though there have been a series of most unfortunate catastrophes and failures with small-tube boilers in both services during the past year. The distinctly adverse opinion of the British boiler committee with regard to this class of generators in large vessels was a decided setback for the type.

The large-tube boilers, now the subject of so much controversy, consist essentially of a group of more or less inclined straight tubes which are jointed to a single or series of vertical collectors, which connect a water collector at the bottom to a cylindrical steam drum at the top. The tubes are single, of the ordinary type, as in the Babcock-Wilcox or Belleville, or of the double or Field type, as in the Niclausse or Durr. These four are the leading types of large-tube boilers and are those with which the principal experiments are now being conducted abroad. The new type of Yarrow boiler, which has found favor in Holland and Austria, might be said to be a compromise, for, while it retains the general constructional arrangement of the small-tube type, its tubes have been made much larger than formerly.

Following will be found notes upon the system of boiler installations in the principal navies with recent experiences in operation and trials. The South American powers, which possess a number of large and important vessels, have in every case had them constructed in British or European shipyards and have adopted the particular type of generator most in favor at the various shipyards, so they have formed no consistent naval boiler policy.

AUSTRIA.

After making rather unsuccessful trials in the *Lussin* with the earlier type of Durr boiler, the Austrian Government adopted the Belleville and Yarrow boiler, and at present they seem to be about equal as to preference.

DENMARK.

This Government has installed the Thornycroft small-tube boiler in its new coast-defense ironclads, following the results of an installation of 8 boilers of this type in 1898 in the small cruiser *Geiser*.

FRANCE.

The French Admiralty have passed through a year of much doubt and uncertainty in regard to boilers, and nowhere has the question of small versus large tube generators raged more furiously. Almost the first to install the water-tube boiler, France has for a number of years

committed herself absolutely to the type. As a consequence we have more types originating in France than any other country, and the French navy has made trial of five systems. These are Belleville, Lagrafel-d'Allest, Niclausse, Guyot, and Normand-Sigandy.

The Lagrafel-d'Allest, a straight inclined-tube boiler, the tubes being dudgeoned into large single headers at front and rear, was early condemned in consequence of a serious accident with this type on the *Jaurèguiberry* and because of the great care required in working them. Before their abandonment, however, they were fitted into a number of important French vessels.

The Belleville and Niclausse boilers have been very extensively used. The former, having been on the market for a longer time, has a greater total of I. H. P. in use than the latter. Recently the orders are about evenly distributed between them. One hears very little complaint from French naval engineers as to their operation, and in fact considerable praise as to the ease with which they may be cleaned, cared for, and repaired.

The Guyot and Normand-Sigandy boilers of the small-tube type have been installed in a number of French vessels, including some of the largest and most important cruisers in the service. Among others are the *Jeanne d'Arc*, *Chateau-Renault*, *Montcalm*, and *Jurien de la Graviere*. These vessels during the past year have undergone an unfortunate series of trials and mishaps, which have done much to destroy faith in the small-tube boiler.

The *Chateau-Renault* had her trials last August, at which time she obtained, in a three-hour trial, the splendid speed of 24.2 knots.

As far as can be learned, during this trial the boilers functioned satisfactorily, and the faults developed were all in the engine room. During a six-hour trial this vessel developed 18,500 horsepower at 118 revolutions, giving a speed of 21.5 knots, with a coal consumption of 1.423 pounds per horsepower hour. These results are excellent.

The *Jeanne d'Arc* was taken out for her first trials the latter part of July. This 11,000-ton cruiser has Guyot boilers designed to furnish 28,500 horsepower for 23 knots speed. Twenty-four out of the 30 boilers were started up. Almost at the beginning it was found that coal could not be directly thrown into the furnaces, but must be put in from one side. The temperature in the fire rooms rose to 155° F. The water feed began to fail and the boilers became red hot. The fire-room force abandoned the stokeholes in a panic, fearing an awful catastrophe, and they were only driven back in order to draw fires in six of the boilers which were at a red heat and 14 in which the water level had disappeared. With the remaining 4 boilers the vessel crawled back into port at a speed of 2 to 3 knots. In consequence of this accident the installation is being extensively overhauled, and the vessel will probably not be ready for her final trial before the com-

ing summer. For the same reason the *Jurien de al Graviere* and *Montcalm* have also undergone extensive modifications in their boilers. In her own trials the *Montcalm* experienced the same excessive temperature in the stokeholes.

GERMANY.

The progress of the boiler question in the German navy will be found exhaustively treated in the appended article by Herr von Jaski. It may be added that the German authorities are strongly actuated by patriotic motives in their selection of the Durr and Thornycroft-Schulz (or, as they prefer to call it, Schulz) boilers, as both these are of German manufacture. Actually the Durr boiler closely resembles the Niclausse, and while it possesses most of the advantages of that boiler, it is claimed by French and British marine engineers to possess certain additional disadvantages. The Schulz boiler is simply a slight modification of the Thornycroft type, and in fact they are now consolidated under the double name.

This latter type of generator has been unfortunate in one or two cases during the past year. On the *Ariadne* in one of her boilers 60 tubes were damaged badly, 39 of them having their ends torn loose from the drum, the other 21 being much twisted. Two men were killed and four injured in the explosion. Later, on the coast-defense ship *Ægir*, while bound out from Kiel, a number of tubes split suddenly, and a burst of flame came out into the fire room, burning badly three petty officers and two firemen.

ITALY.

The Italian navy has confined itself to two types of water-tube boilers, both French—the Niclausse and Belleville—for the new vessels now building, the number of installations being about equally divided. Italy has been conservative in regard to the water-tube boiler, and few finished vessels in her service have them installed. That the Italian Admiralty is desirous of determining a single type to be adopted is shown by the comparative trials of the Niclausse boilers in the *Gari-baldi* and Bellevilles in the sister ship *Varese*.

A board of officers, with a rear-admiral of the Italian navy as president, conducted the experiments. Both ships were placed under exactly the same condition with reference to the cleanliness of their bottoms, trim, and other features, the ships being of the same tonnage. It was intended that there should be continuous trials for a period of sixty hours, but the trial was only continuous for twenty-four hours, November 22–23, 1901, along the route from Naples to Augusta.

The results show that the two types of boilers are practically the same except in regard to the consumption of coal per horsepower-hour and for the consumption of water.

The data of the trials are as follows:

Data.	Garibaldi (Ni Clausse).	Varese (Belleville).
Duration of trials	24	24
Average speed	17.05	16.04
Distance steamed.....	412	392.2
Mean draft at beginning.....	24.1	24.4
Corresponding displacement	7,763	7,940
Number of boilers, main engine	16	16
Boilers for auxiliaries.....	(a)	4
Total grate surface, boilers for main engines.....	67.52	64.12
Total heating surface, boilers for main engines.....	2,821.12	2,077.16
Mean I. H. P.....	6,815.48	6,386.60
Coal per square meter of grate per hour	86.88	78.70
Coal per horsepower per hour.....	1.89	1.76
Horsepower per square meter of grate.....	100.94	99.00
Horsepower per square meter of heating surface	3.12	3.074
Total coal per horsepower-hour, including auxiliaries	2.082	1.94
Approximate consumption of water during trial.....	14,900	20,030

a Four for first two hours and two for rest of trial.

Some of the tubes in both Ni Clausse and Belleville boilers were found to be indented with fine cracks varying to a maximum of from 14 to 15 millimeters. These slight cracks did not require the tubes to be replaced nor any special repairs.

The board reported that after the trials all the boilers were in good condition for any service.

The conclusion was arrived at that in the twenty-four-hour trial the Belleville and Ni Clausse boilers fulfilled all the requirements of regular service, both giving practically identical results.

It is interesting to note, in view of the complaints in this respect of the Bellevilles in H. M. S. *Hyacinth* during the vessel's Gibraltar run, the much greater consumption of fresh water of the Bellevilles than the Ni Clausse.

JAPAN.

The Japanese authorities have always clearly followed in every respect the British Admiralty and most of their larger vessels have been built in British shipyards. Thus, with the extensive adoption of Bellevilles by the British, Japan followed their example. Lately they have begun to install Ni Clausse, the cruisers *Nataka*, *Tsushima*, and *Yacoyama* being thus fitted. This progressive power, though, is not entirely content to use foreign installation and now is fitting in the *Hashidate*, of 4,278 tons displacement, 8 water-tube boilers of a new type, invented by a Mr. Miyahara, a Japanese. This boiler has been used in some mercantile steamers and has been found very successful, but its employment in a man-of-war will commence with the *Hashidate*. As this vessel's sister ships are fitted with Bellevilles, a good opportunity will be afforded for comparative trials.

For small cruisers the Japanese authorities have made use of the

Thornycroft and Normand types, but have not extended their use in larger units.

NETHERLANDS.

This country has recently entered upon a more extensive building programme and in doing so was, of course, confronted by the inevitable question of boilers. In their series of present cruisers the first three were built with a compromise installation of three-fourths Yarrow and one-fourth cylindrical boilers (for ordinary speeds). The Yarrows seem to have given satisfaction, for the later cruisers of this series were fitted with the Yarrow exclusively, as have been the new iron-clads under construction. These boilers are of the large-tube Yarrow type.

NORWAY AND SWEDEN.

The Yarrow boiler has been adopted for the new vessels of these countries. A trial installation of the Babcock & Wilcox type was made in the Norwegian corvette *Ellida*.

RUSSIA.

The Russian navy, following in this question the British navy, at first adopted the Belleville, and there are a number of large vessels equipped with this type. Lately, in consequence of some experiments on the gunboat *Herabry*, the Niclausse system was adopted for the *Variag* and *Retvisan*, and the results of these vessels' trials were successful. Finally it has placed Thornycroft-Schulz and Normand boilers on two large cruisers. It is most likely that the latter resolution was taken in order to make comparisons between the apparatus generally in use now. In connection with this idea Russia has had recently launched from a German shipyard the large collier and training ship for firemen, *Okean*. This vessel has a boiler installation comprising four different types, distributed as follows: Six Belleville boilers, 6 Niclausse, 3 Yarrow, and 2 Thornycroft-Schulz. The engines are to develop 18 knots with 11,000 I. H. P. This novel vessel should prove very useful in the instruction of the fire-room personnel of the Russian service as well as in affording an opportunity for comparing the operation and economy of the types installed. Russia has had only partial success with Thornycroft-Schulz boilers as installed in the *Askold*, which, during her trials, had more than 900 tubes burned out on one trip and was not able to make her contract speed.

SPAIN.

The Spanish navy is now building no new vessels. It has some large vessels still uncompleted on its hands, which were laid down several years ago. It is not easy to determine its preference. It is placing Belleville in the *Rena Regente*, the last vessel on the stocks. The *Pelayo* and the ill-fated *Colon* were fitted with Niclausse. The cruiser *Rio de la Plata* is fitted with Normand-Sigandy boilers. An

article on the means employed in their care and preservation on this vessel in the *Revista General de Marina* for August, 1901, tells us that these boilers were run for fifteen months for a cruise of 24,000 miles without an accident or a plugged tube. Though it is evident that special care was taken and no high speeds demanded in their case, it shows well for the generally condemned small-tube boiler type. The new *Estramadura* is being fitted with Thornycroft-Schulz boilers.

GREAT BRITAIN.

This, the most important naval power, has been left to the last for discussion, because its tests and trials have been so much more extended, more thorough, and more conclusive than those of any other nation that they will best serve as a summation of the perplexing question as it stands to-day. A careful perusal of the report of the Admiralty boiler committee and a thorough and impartial reading of the voluminous editorials and articles, partial and impartial, that have appeared in the British and foreign technical and general press during the year past, can not but lead to the conclusion that we have made little progress toward the solution of the problem, except it be the impulse or pressure that has led the British Admiralty to order a large and varied comparative installation of water-tube boilers in large units. The tests of boilers of various types in destroyers and small gunboats have been interesting and have given us some valuable data, but they have not been conclusive. Most engineering men are satisfied in their minds as to the desirability of some type of small-tube boiler for very fast small craft, just which type being a matter of local opinion and minor consideration. But they are by no means satisfied as to the proper generator of energy for the vital units of the fleet, those upon which the fate of the nation depends primarily, the large battleships and armored cruisers and "commerce destroyers," that all navies are laying down, and in which so many thousands of horsepower are required, and whose boilers represent vast sums of money not to be thoughtlessly expended for this or that preference of the moment, or, when once installed, not easily changed except at great trouble and cost. This is the question which is engrossing the engineering mind to-day, and if the British Admiralty's tests but solve it they will have conferred a most valuable benefit not only upon their own service but upon all the navies, whose officers are following with keen interest the development of the problem. The following article in *Engineering* for January 24, 1902, shows the plans of the Admiralty with respect to these large installations:

THE BOILERS FOR THE NEW BRITISH WAR SHIPS.

Admiralty contractors throughout the country are at the present time engaged in preparing tenders for the construction of 2 battleships, 5 armored cruisers, and 2 third-class cruisers; and the situation is rendered the more interesting in view of the fact that the Admiralty have developed their policy in connection with the boiler question, and thus there is a probability that in these new ships there will be fitted

several different types of steam generators, which have been tested by long sea steaming in various gunboats of the *Sharpshooter* class and in one or two sloops of war. While the Belleville boiler was being extensively applied, experiments were continued with the Babcock & Wilcox, Niclausse, and other types, and thus data have been accumulated which has now resulted, under the stimulus of the water-tube boiler committee, in a greater variety of water-tube boilers for the new vessels. Indeed, the most important question in connection with the two ships has reference to the type of boiler in use. Thus, in connection with the first-class cruisers, of which five are to be built by contract and one in a dockyard, four alternative boiler systems are proposed, although the Yarrow boiler gets first place in the specification, and there is thus more than a suggestion of its securing first consideration.

Although a comparison of the economy, of the facility in working, and particularly of the cost of repairs of such several types applied to one class of ship would be the most important, we must at present be satisfied with an examination of the particulars of design, accepting these as indicative of the steaming capabilities of the different boilers. The power to be developed, it may be said, is 22,000 indicated horsepower; and as in all war ships weight had to be minimized as much as possible so as to secure adequate armored protection, satisfactory bunker capacity, a powerful armament, and a large storage of ammunition, the weight given may be assumed as being the least possible for the power stated with assurance of success. In the primary design 22 boilers of the Yarrow type are specified; in second and alternative arrangement, 25 of the Dürr type; in a third, 34 of the Niclausse, and in a fourth, 25 of the Babcock & Wilcox. The steam pressure at the engines in all cases is the same—250 pounds—but in the boilers of the two last-named types a greater margin is allowed, the boiler pressure being suggested at 270 pounds, while in the Yarrow and Dürr boilers it is 260 pounds; but the difference is immaterial, and obviously no reducing valve is anticipated. The Yarrow boilers have the greatest heating surface per unit of power to be developed—3 square feet per indicated horsepower, as compared with about 2.6 square feet in the other cases, the Babcock boiler having slightly more than the Dürr and the Niclausse. The Yarrow boiler is expected to consume more coal per square foot of grate than the others; the variation in the power expected from the bar surface being considerable—12.2 indicated horsepower per square foot in the Niclausse, 14.4 indicated horsepower in the Dürr, 12.5 indicated horsepower in the Babcock & Wilcox type, and 20 indicated horsepower with the Yarrow boiler. As regards weight, the Yarrow type comes out most advantageously, although the difference is not so great as might have been anticipated, the total being 1,832 tons, whereas the Dürr boilers, with the same machinery, weigh 20 tons more, the Niclausse 60 tons more, and the Babcock & Wilcox 25 tons more; thus the power per ton of weight varies only between 12 and 11.62, as indicated in the table of particulars given:

Comparison of boilers of different types for 22,000 indicated horsepower cruisers.

Type of boiler.	Belle-ville.	Yarrow.	Dürr.	Ni-clausse.	Babcock & Wil-cox.
Number	31	22	25	34	25
Boiler pressure pounds..	300	260	260	270	270
Heating surface..... square feet..	50,300	66,000	57,000	57,200	59,000
Grate area do.....	1,610	1,100	1,525	1,800	1,750
Heating surface per indicated horsepower ..do....	2.29	3	2.59	2.6	2.68
Indicated horsepower per square foot of area.....	13.65	20	14.4	12.2	12.5
Total weight of machinery tons..	1,750	1,832	1,852	1,892	1,857
Indicated horsepower per ton.....	12.57	12	11.87	11.62	11.87

Several cruisers now being constructed are of practically the same type, and known as the *County* class. Belleville boilers are being fitted to most of them, and here the power is exactly the same, so that a comparison is not without interest. The heating surface allowed per indicated horsepower is less than in any of the four alternative designs, being 2.29 square feet as compared with from 2.59 to 3 square feet, while the power per square foot of grate is 13.65 indicated horsepower, as compared with from 12.2 to 20 indicated horsepower. In the matter of weight the Belleville boiler has the advantage, the total, including machinery, being 82 tons less than the lowest of the four alternative designs, and 142 tons less than the highest. This is the more remarkable as the engines do not differ much.

It may be said that the machinery is to be of the triple-expansion type, with four cylinders, as now adopted in all naval practice, the high-pressure having a diameter of 37 inches, the intermediate of 60 inches, and the two low pressures of 69 inches, the piston stroke being 42 inches, so that at 140 revolutions the usual piston speed in navy ships of 980 feet per minute will require to be made to get the power required. The ships are to have a speed of 23 knots, when the displacement is 10,200 tons; this is 400 tons more than in the former ships of the same class, the length being 10 feet more—i. e., 450 feet; breadth, 67 feet, as compared with 66 feet; and the depth, 38 feet 4 inches, or 1 inch more, while the draft is maintained at 24 feet 6 inches. The side armor will be of 4 inches in thickness, and the armament will include, as we described in a recent article, two 7.5-inch guns, with ten 6-inch weapons, as well as a large number of smaller guns.

In the case of three battleships to be built, the question of boilers is equally interesting, as in this case Babcock & Wilcox boilers are to be adopted in two, while in the third there is proposed a combination of cylindrical with this same design of water-tube steam generator. Here, again, comparison is possible with the Belleville system, for the new battleship machinery will be very similar to the engines of the six vessels of the *Duncan* class now being completed, in which Belleville boilers are used to get the same power of 18,000 indicated horsepower from engines whose cylinders are of the same diameter as those in the new *King Edward VII* class. As to weight, the whole machinery, with the Belleville boiler works out at 1,580 tons, while with the Babcock & Wilcox system the total becomes 1,735 tons, and with cylindrical boilers providing two-fifths of the power the total is 1,885 tons, or 300 tons more. It is scarcely necessary to labor the point that this extra weight involves forfeiture of some of the offensive or defensive qualities of the ship, or an increase in the weight and size of the ship to provide for the heavier boilers, and again for the extra material resulting for large dimensions of hull. Here are the leading particulars of the three systems:

Comparison of boilers for 18,000 indicated horsepower battleship.

Type.	Belleville.	Babcock & Wilcox.	$\frac{3}{8}$ Babcock & Wilcox, $\frac{5}{8}$ cylindrical.
Number	24	16	14 and 6
Steam pressure.....pounds..	300	270	210
Heat surface.....square feet..	43,260	47,250	27,380 and—
Grate area.....do.....	1,375	1,400	817 and 486
Heating surface per indicated horsepower.....square feet..	2.4	2.63	.....
Indicated horsepower per grate area.....	13.1	10.4	.....
Weight of machinery.....tons..	1,580	1,735	1,885
Indicated horsepower per ton of machinery.....	11.4	10.37	9.54

It will thus be seen that the indicated horsepower per ton of machinery is, with the combination, 9.54 indicated horsepower, and

with the Babcock & Wilcox 10.37 indicated horsepower, as compared with 11.4 indicated horsepower in the case of the Belleville boilers. With the inclusion of the tank boiler in the steam generation system, a reduction of pressure has been made imperative, from 300 pounds and 270 pounds, respectively, with the purely water-tube-boiler arrangements to 210 pounds, and this, again, has rendered larger cylinders, etc., necessary. Thus, in the *Duncan* class and again in the two ships of the *King Edward VII* class, to have Babcock & Wilcox boilers the diameters are to be the same, 33½ inches in the case of the high-pressure, 54½ inches in the intermediate, and 63 inches in the two low-pressure, while in the vessel with the double system of boilers the diameters are 38, 60, and 67 inches, respectively, the stroke continuing the same, 48 inches, and also the piston speed, 960 feet for 120 revolutions. The reduction in steam pressure may, however, lessen the loss in auxiliary machinery when working simple or even compound, but a large part of this loss in economy has already been compensated for in high-pressure steaming ships by the use of the exhaust from these in distillers, etc., or by passing it into the intermediate or low-pressure cylinder receiver. However, we have no intention of speculating as to the probable results of the changes; the particulars of design are alone interesting enough for the present. It may be added, however, that the new battleships are to be 425 feet long, 78 feet beam, and 43 in depth, and at 26 feet 9 inches draft they will displace 16,350 tons. Their speed is to be 18½ knots. As to the guns, we have dealt with them in a previous article (*Engineering*, vol. lxxii, p. 715).

At various times during the year the small vessels fitted with trial installations of water-tube boilers have had test runs. The *Sheldrake* and *Espiegle* were fitted with Babcock & Wilcox boilers and the *Fantome* with the Nielausse type.

The trials of His Majesty's sloop *Fantome* in January last were specially interesting, as they were conducted under the direction of the water-tube boiler committee, this vessel being the first to be fitted with the Nielausse boiler since it was experimentally tried in a torpedo gunboat of the *Sharpshooter* class. On the low-power run the mean result was 339 indicated horsepower, with a coal consumption of 1.695 pounds, while the sister ship, *Espiegle*, with Babcock & Wilcox boilers, at 337 indicated horsepower, consumed only 1.53 pounds; two Belleville-boiler ships, *Mutine* and *Rinaldo*, at the same power, burning 1.86 pounds and 1.90 pounds, respectively. On the second thirty hours' trial, at 75 per cent of the full power, the Nielausse-boiler ship, at 1,020 indicated horsepower, equaled that with the Babcock boilers, the rates being, respectively, 1.53 pounds and 1.54 pounds, while the Belleville ships named returned 1.72 pounds and 1.60 pounds. On the full power the Nielausse-boiler ship did well again. Her power was 1,453 indicated horsepower, speed 13.63 knots, and coal consumption

1.53 pounds. The *Espiegle*, with the Babcock & Wilcox boilers, consumed 1.70 pounds, and the two Belleville-boiler vessels 1.63 pounds and 1.61 pounds, respectively.

In the last issue of these notes appeared the ad interim report of the admiralty water-tube boiler committee, and an account of the earlier trials of H. M. S. *Minerva* and *Hyacinth*. These were followed in the spring of 1901 by a series of short trials and runs preliminary to the great test run to Gibraltar and back July 6 to 20, 1901, the report of which is appended here as of much value. There was extended comment and discussion as to the results of this run, and the boiler committee made a brief preliminary report on August 6, 1901. The following editorial from the London Times of August 28 covers the comments of this report and the general scope of the situation very thoroughly:

The official "particulars of the recent sea trials of the *Minerva* and *Hyacinth*" which we printed on Monday constitute a fresh and most instructive chapter in the long and momentous controversy concerning the boilers of His Majesty's warships. But they do not by any means close the controversy. On the contrary, they merely illustrate the extreme difficulty and increasing complexity of the problem which the boiler committee is attempting to solve. The trials of which the official particulars have now been published were not, it should be premised, speed trials nor engine trials; they were emphatically and exclusively boiler trials—an attempt to determine by a full-speed run to Gibraltar and back whether the Belleville boiler as fitted in the *Hyacinth* or the cylindrical boiler as fitted in the *Minerva* is the better boiler for use in the ships of His Majesty's navy. So far as speed is concerned the *Minerva* distinctly had the best of it, seeing that on the run home she attained and maintained a higher speed, with an average of 1,000 less indicated horsepower, than the *Hyacinth*. But there is nothing to show that the defective speed of the *Hyacinth* at the highest power developed was due in any respect or degree to the nature of her boilers. On the contrary, Admiral May, the controller of the navy, distinctly says, in his very terse and instructive report on the trials, that "this extra I. H. P. must have been absorbed either in the engines, or on the main shafts bearings, or in the hull;" and it needs no engineering knowledge to understand that, if a ship goes no faster, or even goes slower, with $x + 1,000$ I. H. P. supplied from the boiler, than she goes with x I. H. P., it is not the boiler that can be blamed. Indeed, it is distinctly to the advantage of the *Hyacinth's* boilers that they could attain, and did attain, an average of 9,400 I. H. P. and a maximum of 10,000 for at least two hours, whereas the *Minerva* attained only an average of 8,400 I. H. P., and a maximum of 8,700 in circumstances about which we will have something to say presently. As regards coal-consumption, again, there appears to be very little difference between the two ships. When developing 7,000 I. H. P. the coal carried by the *Hyacinth* would enable her to steam 2,930 miles, while in the same conditions the *Minerva* could steam 3,000. As no ship ever does, or in time of war ever could, run to within measurable distance of the extreme limit of her coal supply, this difference of 70 miles is, for practical purposes, almost inappreciable.

These, however, are not the chief issues which the trials were instituted to determine. The essential question is, What are the relative merits and disadvantages of the two types of boiler, as displayed in a sea trial at high speed, maintained as continuously as was consistent with prudent navigation, throughout two successive runs of over 1,000 miles? In general terms the answer appears to be that there is not very much to choose between them. As regards the rapidity of getting up steam for

the prescribed power the difference was insignificant. On the run out both ships sailed at 3 p. m. under orders to maintain 7,000 horsepower until all of the coal, except that in the reserve bunkers, was exhausted. At 3.45 p. m. the *Hyacinth* had attained 6,994 horsepower, and the trial was considered to have started from that time. The *Minerva* reached the same stage a quarter of an hour later. On the run home the ships, having only such boilers alight as were required for auxiliary purposes in harbor, but having employed steam supplied by these boilers to warm their engines beforehand, were ordered by signal at 4.27 p. m. to light fires in the boilers not at work and to proceed to Portsmouth as fast as possible. Three minutes later the engines of both ships were being worked slowly with steam supplied from the boilers already alight, and fifty minutes later the *Hyacinth* was proceeding at 150 revolutions per minute, the horsepower being nearly 7,000. The same stage was reached by the *Minerva* in forty-four minutes, but during the ensuing two or three hours her engines had to be eased several times "on account of eccentric straps warming up."

This result is eminently noteworthy, as one of the advantages claimed for the water-tube boiler is the rapidity with which steam can be raised. Yet in the particular cases under consideration there seems to have been little or nothing to choose between the two. So much for the beginning of the run. Before its end several things had happened. Owing to serious leakage, due chiefly to defective joints and tubes, the loss of water in the boilers of the *Hyacinth* was very large. She had a reserve tank stowage of about 140 tons, and it was arranged that up to a certain point the only make-up feedwater should be obtained from this source. In about sixty-two hours this supply was reduced to 35 tons, and evaporators were then started to augment it. In less than forty-eight hours more the engines had to be eased owing to the continued loss of water, and the further trial had to be abandoned after 25 tons of drinking water had been used for boiler make-up, in addition to all that had been taken from the reserve tank supply and all that could be obtained from all the evaporators in full work. In other words, the *Hyacinth* had to abandon the trial before her coal was exhausted because she could no longer supply water to her boilers. The *Minerva*, experiencing no similar difficulty, was able to continue the trial for some forty-four hours longer. "The average horsepower of the *Hyacinth* was 7,047 for one hundred and three and one fourth hours with a coal consumption of 1.97 pounds, and the distance run was 1,810 miles at an average speed of 17.6 knots. The *Minerva's* horsepower was 7,007 for one hundred and forty-seven hours with a coal consumption of 2.06 pounds, and the distance run was about 2,640 miles at an average speed of 17.96 knots." Thus the *Hyacinth* had a slight advantage in coal consumption and the *Minerva* a slight advantage in speed, though this latter advantage was of course not due to the boilers, and may have been brought about by the prevalence of clear weather after the *Hyacinth's* trial was abandoned. On the other hand, the effective range of the *Minerva* exceeded that of the *Hyacinth* by some forty-four hours and some 830 miles. Thus far, then, the advantage would seem to lie quite unmistakably with the *Minerva*, nor were the difficulties experienced by the *Hyacinth* in maintaining a due supply of water to her boilers appreciably lessened on the run home.

But we have not yet considered the difficulties experienced and the defects exhibited by the *Minerva*. They were far from inconsiderable, though they were of quite a different nature. "On arrival at Gibraltar," to quote the comment of Admiral May, "the cap ferrules were found to be partially choked, * * * and the ship could not have gone any farther at that power (7,000 I. H. P.). As it was she was using up to 1.7 inches of air pressure instead of one-half inch to maintain the necessary combustion for this power. On arrival at Portsmouth practically the same thing occurred." This is a very old story in connection with cylindrical boilers, especially under "forced draft"—a phrase little heard of latterly, though at one time the

device it describes was denounced by naval engineers almost as vehemently as the Belleville boiler is denounced in some quarters now. It is little heard of because it is practically abandoned, the normal pressure sanctioned by the Admiralty having been reduced to the half inch mentioned by Admiral May. Yet in order to obtain the favorable results exhibited in the recent trial the *Minerva* was obliged to resort to more than three times this pressure, because her tubes had become choked as tubes often did become choked in the days when the cylindrical boiler gave almost as much trouble as the water-tube boiler gives at present.

Now, the cylindrical boiler has been in use for years, and though its superiority to the water-tube boiler is held in some quarters to be axiomatic and indefeasible, yet under the stress of severe and prolonged trial it is found still to exhibit its old characteristic defect. On the other hand, the water-tube boiler also exhibits its own characteristic defect, different indeed, but in certain circumstances of even more serious moment. But the water-tube boiler is a comparatively new appliance. We have not had years to study it and bring it to perfection as we have had with the cylindrical boiler. It is far from perfect, and its imperfections are at once very serious and very baffling. But, unlike the corresponding imperfections of the cylindrical boiler, they have not yet proved to be persistent and apparently irremediable after many years of varied experience and use. They seem to spring mainly from the difficulty of making joints and tubes strong enough and sound enough to withstand an internal pressure of some 200 to 300 pounds to the square inch. But this difficulty ought not to be insurmountable, and unless we are misinformed it has already been surmounted to a very large extent in the French navy. Apart from this there is little or nothing in the recent trials to show that the Admiralty were ill advised in adopting the water-tube boiler, of which it must be remembered there are many other types besides the Belleville. It has now been adopted in every important navy in the world. If because we have not yet learned how to make it in perfection and how to use it to the best advantage we were to abandon it in favor of the cylindrical boiler, we might find that we had made as great a mistake as we made when we went back to muzzle-loading guns because our early breechloaders were unsatisfactory and defective in many important respects.

Concurrently with these trials the committee made a series of trials with the large merchant steamer *Saxonia*, of the Cunard Line, on a run between Queenstown and Liverpool. She is a twin-screw vessel of 9,000 to 10,000 I. H. P., with 4-cylinder, 4-crank, quadruple-expansion engines, having cylindrical boilers working at a safety-valve pressure of 210 pounds and fitted with Howden's draft arrangements. These showed very great efficiency, reaching the unusual figure of 82.3 per cent, and showing an evaporation of 12.3 pounds of water per pound of coal, and a coal consumption of 1.29 pounds per horsepower hour. These results are valuable as showing what may be obtained under the simple conditions of the merchant service, where speed is nearly always constant and there is plenty of room. It would not be fair to compare them critically with man-of-war results.

The special boiler committee, still unsatisfied, have decided to repeat the programme and steam trials of the cruisers *Hyacinth* and *Minerva*, including the race to Gibraltar and back. Before this, however, the vessels are to steam over the deep-sea course off the Cornish coast at speeds of 16 to 18 knots and at full natural draft speed. After three runs over the course at each of these speeds the *Minerva* will go to

Stokes Bay for a series of runs over the measured mile at 10, 13, 16, and 18 knots speed.

One of these trials took place on April 21 over the deep-sea course between Rame Head and Dodman Point, the *Minerva* having rather the better result.

The trials are especially interesting by reason of the fact that the vessels commenced the trials together, and therefore experienced the same conditions of wind and tide. With smaller indicated horsepower the *Minerva* attained a higher speed than the *Hyacinth*, the mean result of four runs being: *Minerva*, I. H. P. 4,903, speed 15.97 knots; *Hyacinth*, I. H. P. 5,007, speed 15.60 knots.

These vessels later continued the series of trials under the supervision of the special boiler committee. Leaving Plymouth Sound together, they made four runs on the deep-sea course between Rame Head and Dodman Point. The result was again in favor of the *Minerva*, the vessels attaining practically the same speed, with a difference of 657 I. H. P. to the credit of the *Minerva*. The mean results were: *Minerva*, I. H. P. 7,343, speed 17.671 knots; *Hyacinth*, I. H. P. 8,000, speed 17.669 knots.

The final trial was at full natural draft. The *Hyacinth's* mean speed was 18.59 knots, with 10,170 horsepower, and that of the *Minerva* 18.28 knots, with 8,405 horsepower. The *Minerva* was, therefore, beaten in speed by 0.31 knot when the *Hyacinth* was doing her utmost, while the former ship had 1,195 horsepower in reserve, which she was not allowed to use. Taking the series of trials carried out during the week, the speed of the *Hyacinth* has not apparently improved since the run to Gibraltar last year.

THE WATER-TUBE BOILER QUESTION IN THE GERMAN NAVY.

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I.—ORIGIN OF THE WATER-TUBE BOILER QUESTION.

The rivalry between ships' guns and armor and the endeavors which are constantly being made to increase the speed and extend the radius of action of war ships have added so greatly to the weights that have to be carried by ships that it has become a matter of grave concern to save weight wherever it can be done if the displacements are not to become unduly large and the cost of construction is to be kept within the limits of the amount placed at the disposal of the constructors for naval purposes.

Up to a certain point it has been possible to lessen the weight of the guns by improved methods of construction, and the weight of the armor by making it of better material; the weight of the coal required has also been diminished by more economical engines. The use of mild steel (flusseisen) of greater strength has allowed of a reduction being made in the dimensions of a number of constructive details which as a consequence has admitted of not only the larger engines now required, but also of the hulls being built relatively lighter than was formerly

possible, e. g., the actual weights of the hulls of the old armored ships, *König Wilhelm*, *Kaiser*, and *Deutschland*, when they were built varied between 44.96 and 38.86 per cent of their total displacements, whereas the actual weight of hull to total displacement in the new battleship *Kaiser Friedrich III*, is only 31.64 per cent. The saving in weight, however, was still insufficient. The heavy guns of large caliber were replaced by lighter and more efficient guns of smaller calibers, and by Q. F. guns. A short 30.5-centimeter (12-inch) hooped gun, with a striking energy of 4,680 meter-tons (15,112 foot-tons), weighed 36 tons, whereas a modern long 24-centimeter (9.45-inch gun), with a total striking energy of 4,349 meter-tons (14,043 foot-tons), weighs only 25.8 tons, being thus 30 per cent lighter, with a diminution of only 7 per cent of energy. The new arrangement moreover allows of a greater number of guns with hydraulic training gear and a much larger amount of ammunition being put on board, so that the proportion of the weight of the gunnery and torpedo armament to the total displacement is not really less. Thus, while the weight of the guns in the old armored ships *Kaiser* and *Deutschland* was 6.74 per cent and in the *König Wilhelm* 8.21 per cent of the total displacements, the percentages in the battleship *Kaiser Friedrich III* are 7.42 per cent for the guns and 1.05 per cent for the torpedo armament, making a total of 8.47 per cent for gunnery and torpedo armaments combined.

The improvements in armor allowed of thinner and consequently lighter plates for a given resistance being substituted, but at the same time the protection had to be increased correspondingly with the greater penetration acquired by the enemy's projectiles. The heavy guns therefore had to be protected by armored turrets, the ammunition hoists had also to be armored, and the main engines and boilers likewise necessitated the addition of protective decks; hence the weight of armor had to be considerably increased. Thus, while the weight of armor in the older ships was only 21.82 per cent in the *König Wilhelm*, and 23.14 in the *Kaiser* and in the *Deutschland*, the percentage in the battleship *Kaiser Friedrich III* rose to 34.31 per cent of the total displacement. Then, again, the demand for greater speed led to a distinct increase in the weight of the machinery installations, and to an ever-increasing percentage of the total displacement being required to meet it. Thus, the percentages of the weights for engines and boilers to the total displacements of the ships named are as follows for the older ships: *König Wilhelm*, 11 per cent; *Siegfried*, 10.9 per cent; and *Sachsen*, before reconstruction, 13.3 per cent; as against for the newer ships *Prinzess Wilhelm*, 20.8 per cent; *Kaiserin Augusta*, 23.7 per cent; *Jagd*, 24.6 per cent, and *Meteor*, 26.2 per cent. The task, therefore, imposed upon the engine makers for war ships was how to obtain further economy in the weight of the machinery installations.

This demand was all the more difficult to meet by reason of the introduction of increased expansion of the steam, which, while it diminished the consumption of coal, and consequently increased the radius of action of ships, led to the employment of high-pressure steam. This had necessarily to be followed by increased strength of all such parts of the machinery as are subject to steam pressure, more especially in the plates of the large cylindrical boilers, all of which meant considerable increase in the weight of the boiler installations.

At first an attempt was made to obtain a large amount of steam from small boilers by forced draft, but the cylindrical and locomotive types of boilers, which were then generally used, proved but little suited for the purpose. When steaming under natural draft the layer of coal on the bars is kept thin, and the products of combustion are diluted with a large excess of air. Owing to this the temperature in the furnace is kept comparatively low. Under these conditions only a small quantity of heat per unit of time is transferred to the water in the boiler through the plates of the furnaces and combustion chambers. But when steaming under forced draft the fires are kept very thick, and this, together with careful stoking,

allows very little more air to pass through than is theoretically required for the combustion of the fuel; consequently the temperature in the furnace is much higher than with natural draft, and a large amount of heat per unit of time is transferred to the water in the boiler through the plates of the furnaces and combustion chambers. These plates will consequently become much hotter than when steaming with natural draft, while the rigid construction of the cylindrical and locomotive boilers does not allow of the increased expansion due to the higher temperature of the plates taking place. The effect of heat on the various parts of boilers will be seen by referring to the plans of boilers shown in figs. 1 to 4. The walls *a* are heated to the temperature of the steam, that is to say, with a steam pressure of 12 kilograms per square centimeter (170 pounds per square inch) to 190° C. (374° F.); the walls *b*, however, under forced draft, and with the fires properly stoked, attain a temperature of from 360° to 400° C (680° to 752° F.). If the temperature of the furnace plates is taken as being only 370° C., the plates *b* are thus 370°—190°=180° C. (356° F.) hotter than the shell plates *a*, and consequently with a coefficient of expansion of 0.0000123 and a length of furnace, say, of 2,400 millimeters, would, if free, expand some $180 \times 0.0000123 \times 2,400 = 5.3$ millimeters (0.209 inch) more than the boiler plates *a*. As, however, the necessary fixing of the front end of the boiler does not admit of this large expansion of the furnace plates inside, this expansion—taking the size of the furnace box of a locomotive boiler as being 4,400 millimeters (14 feet 5.23 inches) and the thickness of the plates as 16 millimeters (0.63 inch) as would be about right for ships' boilers, and the coefficient of elasticity as 21,500—means a stress on the rivet seams *c* and on the tube joints in the tube plate *d*, which on the calculation $P = \frac{21,500 \times 4,400 \times 16 \times 5.3}{2,400}$ is equal to 3,038,700 kilograms (3,090 tons). It is clear

that no riveted seam can withstand such a stress for any length of time, and still less the joints of the tubes in the tube plates. For this reason the furnaces in cylindrical boilers are made of corrugated plates, which alter their form under the expansion due to the heat; the resistance, however, which a corrugated tube opposes to this change of form is still very considerable, and the stress arising in the longitudinal direction of the furnaces must be taken up by the riveted seams, while this expansion stress also affects the tightness of the joints of the tubes in the tube plates. As a consequence, such frequent and heavy leakages occurred in the seams *c* and at the tube plate that any heavy forcing of this boiler had to be abandoned.

Here again, therefore, the construction of ships' machinery soon came to a full stop, and it became a matter of necessity to drop the present system of boiler construction if a further saving in weight was to be effected.

That considerable saving in weight in the boiler installations could be obtained by substituting water-tube for the heavy cylindrical and locomotive types of boilers was well known to experts; but previous experiments which had been made with boilers of this type had invariably to be discontinued because of the disadvantages which then attended the use of water-tube boilers, and which appeared to be insurmountable. The same constructors of machinery for war ships who at first fought against the introduction of water-tube boilers, have, however, in the search after lighter installations, been forced step by step to give way, until now their construction is perforce being accepted in all navies. It is true that such a decision has not been arrived at without much searchings of heart, for the constructors were well aware of the fundamental disadvantages of these boilers, and that in adopting them they would have to contend against the force of habit and the prejudices of the personnel against the innovation. After deciding upon their introduction there followed a series of experiments with the various types of water-tube boilers most in favor, with a view to selecting such types as were most suitable for use on board ships of war. These experiments were of course characterized by the skeptics as failures on the part of the constructors, while the cylindrical and locomotive types were proclaimed as being the only suitable types, if only they were not forced too much.

II.—OTHER REASONS FOR THE INTRODUCTION OF WATER-TUBE BOILERS.

Among other reasons telling largely in favor of the introduction of water-tube boilers on board ships of war were the following:

1. *Ability to raise steam quickly.*—The cylindrical and locomotive boilers hitherto used are not only very sensitive to forced draft, but also to quick raising of steam, as their larger water capacity necessitates more coal being burned in raising steam, because of the large amount of heat required to heat up the water; for instance, the ships of the *Brandenburg* class with the water in their boilers cold before lighting the fires, require, if there is no special hurry, and the boilers can consequently be considered, to have the fires burning for eight hours before the ships can go at full speed, and only in case of necessity can steam be raised in from three to four hours in a cylindrical boiler filled with cold water. In war time, especially on blockading service, it will, however, often be necessary to keep the ships lying to for considerable periods, and yet to have them ready to start at the shortest notice. In order to save coal it is desirable that the fires should be out while the ship is stationary, but if three or four hours are required to raise steam, and before she can be ready to start, it would be necessary to keep the fires banked. According to experiments carried out by H. I. M. S. *Kurfürst Friedrich Wilhelm* during the summer of 1899, the coal consumption for this must be calculated at the rate of 200 kilograms per square meter (40.96 pounds per square foot) of grate area per day, so that for a ship with 12 boilers, each having a grate area of 5.85 square meters (54.7 square feet), 2 boilers having steam up and 10 being banked, the daily coal consumption would amount to $58.5 \times 2 = 11.7$, or roughly about 12 tons. In order to try and diminish this heavy coal consumption, the first squadron during the same summer successfully tried the experiment of keeping the water hot in the boilers not in use by injecting steam into the water of those at rest with the hydrokineter worked from the boilers kept under steam for driving the dynamos and auxiliary engines. To do this for five days in 6 boilers the coal consumed per day was only 3.65 tons; consequently, in order to keep the water hot in 10 boilers the consumption would be $\frac{10 \times 3.65}{6} = 6$ tons per day, or just one-half the amount required for keeping the fires banked. In any case, however, if the ship has to remain stationary for any considerable time, the coal consumption in a ship fitted with water-tube boilers is less than in one with cylindrical boilers. According to the experiments carried out by H. I. M. S. *Ägir*, in order to raise steam in water-tube boilers with a grate area of 58.5 square meters when the water was quite cooled down, some 14 tons of coal are required; after lying to, therefore, for two and one-third days, there would already be an advantage in raising fresh steam in water-tube boilers rather than in keeping the water in cylindrical boilers hot by means of hydrokineters.

With cylindrical boilers where the water has been kept at the boiling point by the hydrokineter used in connection with the other boilers, it is possible to raise steam in from fifty to seventy-five minutes. With water-tube boilers steam can be raised in twenty-five minutes without endangering the boiler; it must, however, be borne in mind that large ships' engines, with their long steam pipes, after lying for some days at rest, can not be sufficiently warmed up in twenty-five minutes to allow the engines to be started. About one hour is required after the engines have been at rest for a long time before all the parts have become sufficiently warm as to obviate all fear of water shock in the steam pipes and cylinders. In order to be ready to start at half an hour's notice several boilers must be kept under steam, and the engines must be kept warmed even when a ship has water-tube boilers.

2. *Facility in changing the speed.*—Just as it is possible with water-tube boilers to raise steam more quickly than with cylindrical or locomotive boilers, so also is it possible to carry out quicker changes in the speed of the engines. Mention has already been

made of the great stress on the boiler connections, i. e., on the riveted seams and on the joints of the boiler tubes in the tube plates through the expansion of the furnaces built into the outer shell of cylindrical and locomotive boilers. Of still greater danger to these connections, however, are the partial or local overheating and cooling of the furnaces caused by the grate being unevenly covered with coal, for it is just through the alternate expansions and contractions of the plates, especially when they occur irregularly in different places, that the connections work loose. If the speed of the engines is suddenly increased, the forcing of the boilers has to be similarly suddenly increased, and then the danger becomes greater, because a higher air pressure is obtained before the grate is covered with a uniformly thick layer of coal. This is also the reason why, when forced draft is used with cylindrical and locomotive boilers, the fires have to be kept thick; whereas the less sensitive water-tube boilers are always heated with thin fires even under high forced draft.

3. *Facility in erecting and taking to pieces.*—Large cylindrical and locomotive boilers are very difficult to fit in place on board and to take out again. If it becomes necessary to remove a boiler to effect large repairs in the shop, or if a boiler has to be replaced by a new one, the whole of the deck over the boiler in question has to be taken up and a very considerable disturbance of fittings takes place. On the other hand, a water-tube boiler can be taken to pieces in the boiler room, and after renewing any of its parts it can be completely built up again in place.

4. *Less danger from explosion.*—Explosions in water-tube boilers are less dangerous than in cylindrical and locomotive boilers. If the working of the boiler is carefully supervised, and if the boiler is subjected to regular and adequate inspection, barring extraneous causes, there is little reason to fear any defect of the plates in cylindrical and locomotive boilers, but the want of water has too often been proved to be the cause of accidents in the working of ships' boilers. When such is the case, the crown of the combustion chamber becomes red-hot, and this is followed by the stays drawing out of it. If under such circumstances the combustion chamber crown does not split, such an amount of steam pours out from the holes made in it that excessive pressure takes place in the furnace, and the furnace doors are blown out, and the stokers are scalded. Accidents of this sort occurred in 1892 to divisional torpedo boat "D 5," and in 1899 on board H. I. M. S. *Wacht*. With water-tube boilers, on the other hand, the cylindrical-shaped steam collectors are the highest parts containing water, and these are either not exposed to the fire or are reached only by the comparatively cooled gases. Even, however, if the plates of this steam collector, which in small-tube water-tube boilers also form the tube walls, should become red-hot from a prolonged absence of water, and some of the water tubes should draw out, the steam outlets caused thereby would be so close to the uptake that the greater part of the steam would escape through the funnel, and would only enter the stokehold if the furnace door were open. In any case the small amount of water would be quickly evaporated and the small quantity of steam which might enter the stokehold could not be as disastrous in its effects as the steam coming from a cylindrical boiler, in which the quantity of water is four or five times greater. This difference will be specially emphasized if a boiler or steam pipe inside the boiler room should be shot away in action. In such case the sudden escape of high-pressure steam would prevent the stop valve to the other boilers from being closed, and the whole of the steam from the other boilers directly connected with the damaged boiler or steam pipe would escape into the boiler room. Even if the shot striking the boiler should not bring about a disastrous explosion involving the whole ship, as seems probable from the experience of cylindrical boilers exploding when working on shore, the large amount of steam escaping from the boilers would drive in the boiler-room bulkheads and probably involve other parts of the ship. The disastrous effects caused by water-tube boilers, with one-fourth or one-fifth the amount of steam, would certainly be smaller.

III.—DISADVANTAGES OF WATER-TUBE BOILERS.

Against the foregoing remarks telling in favor of water-tube boilers when compared with cylindrical and locomotive boilers, there must, however, be placed various peculiarities inherent to these boilers which are very inconvenient when working on board ship.

1. *Necessity for regular feeding.*—The advantages attending the small water chambers of water-tube boilers have been referred to in II, 1 and 4, but this small supply of water has, on the other hand, the attendant disadvantage that there is no reserve to equalize slight irregularities in the feeding, and that the rate of feeding must be very quickly altered when the output of steam from the boiler is increased, as otherwise shortness of water will occur.

Water-tube boilers consequently need very careful feeding and very complicated automatic feed-water regulators, which must be carefully attended to and closely watched, as they often have to be adjusted by hand under varying conditions of forcing. Descriptions and drawings of these feed regulators will be found in section 69 and plate 51 of the third edition of *Schiffsmachine*, by Carl Busley.

The regulator, which is often placed in the steam collector, greatly restricts the available space in the collector, and leads, if made of bronze, to galvanic action being set up, which tends to wear away the boiler plates. Even when the feed regulator is arranged outside, for which there is not always room available, the action of the float is liable to be irregular when changes are made in the rate of evaporation in the boiler. Regulating the feed of water-tube boilers by hand, however, is hardly possible because of the changing speeds of the engines and the somewhat irregular stoking of the fires.

2. *Necessity for regular stoking.*—Just as is the case in regard to the water spaces so also the steam spaces in water-tube boilers are small, often to the extent of being only one-fourth of the capacity of cylindrical boilers having the same amount of grate area. As a consequence the reserve of steam is insufficient to compensate for slight irregularities in the management of the fires and in the speed of the engines. In order to restrict these irregularities as much as possible a special system of stoking has been devised by which the fires are kept very thin—4 to 5 inches thick only—even when heavily forced, and regular intervals are laid down for stokers to fire up corresponding with the amount of forcing employed. The amount of coal thrown on at a time is some 1.64 pounds per square foot of grate area; hence, if under forced draft and burning 32.27 pounds per square foot per hour, the furnaces have to be fed twenty times an hour. There is thus an interval of only three minutes between each stoking, and although but a few shovelful have to be thrown on at a time the stokers scarcely obtain any rest, and the labor is consequently very much more irksome than when longer intervals occur. Moreover, not taking into account the management of locomotive boilers on board torpedo boats, much greater forced draft is used with water-tube boilers as a rule than with cylindrical and locomotive boilers; hence more coal is used per foot of grate area per hour, and equally, of course, per furnace per hour, thereby exacting greater exertions from the individual stoker. As a matter of fact, this excessive labor is not so much to be laid to the charge of the nature of water-tube boilers themselves as to the fact that their construction renders possible a greater forcing of the fires.

In order to keep the fires uniformly thin, more skilled stoking is required than to keep thick fires. The personnel consequently needs to be specially trained in the management of water-tube boilers, and unless the stokers are properly trained full efficiency in the boilers can not be relied upon. With a personnel coming fresh on board who are unaccustomed to the management of water-tube boilers, irregular working is pretty sure to occur, whereas the stokers who join the navy from the mercantile marine are necessarily familiar with the management of cylindrical boilers.

3. *Necessity of keeping water surfaces clean.*—Any steam boiler becomes endangered if the conductivity of the heating surfaces or of individual parts of these surfaces is too much reduced through the fouling of the water-washed sides, for the heat impinging from the fire on the boiler walls being no longer able to pass to the boiler water causes the walls to become red-hot. The materials used in the construction of boilers when they become red-hot possess very little strength, and, as a consequence, when the walls attain this condition they are no longer able to withstand the pressure of the steam. Whereas, however, the thin tubes in cylindrical and locomotive boilers derive assistance from the surrounding water under the steam pressure. The effect of the pressure inside the thin tubes of water-tube boilers is to cause them to burst. If, therefore, fire tubes get red-hot they become flattened, ∞ , and although leakage may take place at the joints of the tubes in the tube plates, no large openings are made for the escape of the water in the boiler. On the other hand, in water-tube boilers red-hot water tubes burst, and it is then impossible to prevent practically the whole of the water and steam in the boiler from being blown into the furnace, which may lead to the stokers being scalded if the furnace doors are not kept shut. In any case, however, when a tube bursts the water-tube boiler becomes unworkable until the defective tube can be replaced by a new one, or, in the case of small-tube water-tube boilers, until the hole in the tube plate can be stopped. The danger of explosion consequent on foulness of the inner heating surfaces is thus considerably greater in water-tube boilers than in cylindrical or locomotive boilers. There is truth, therefore, in the saying that water-tube boilers are very sensitive to impure feed water.

4. *Difficulty of cleaning the water surfaces.*—Small-tube water-tube boilers are difficult to clean because the tubes are not easily accessible. Curved tubes especially can not be examined, and it is therefore not possible to ascertain whether the tubes are quite clean inside. Large-tube boilers, on the other hand, can be thoroughly cleaned and examined, but they have a large number of separate doors, and therefore take up much time and labor in cleaning. The numerous screwed connections also give rise to frequent repairs.

IV.—CHOICE OF TYPE OF WATER-TUBE BOILERS..

As soon as our naval constructors had decided, after weighing the pros and cons referred to in I, II, and III, to place water-tube boilers in our war ships, the difficult question arose as to which of the then known types should be adopted.

1. *Rigid constructions.*—After what has been said in I and II as to the great sensitiveness of cylindrical and locomotive boilers under heavy forcing of the fires, quick raising of steam, and irregularities in the management of the fires, all water-tube boilers were at once excluded whose tubes, like the fire tubes in these boilers, are rigidly fixed between stationary water chambers. As it was a matter of rendering feasible heavy forced draft and sudden changes in the condition of the fires without risk of leakage occurring in the tube joints, there could be no question of employing the D'Allest, Steinmüller, Heine, or any other similar boilers (figs. 5 and 6), which may possibly be quite satisfactory water-tube boilers under other conditions of service. It is true that in the French navy the *Charles Martel*, the *Carnot*, the *Du Chayla*, the *Cassard*, the *Kersaint*, the *Jauréguiberry*, the *Masséna*, the *Bouvines*, the *Valmy*, the *D'Assas*, the *Foudre*, and the *Casabianca* have been fitted with D'Allest boilers, but it has been proved that they require such care in working that they are no longer being put into French war ships.

2. *Slightly elastic constructions.*—Those boilers also in which either one or both water chambers can move, and so follow the expansion of the tubes, also logically appear to be excluded if straight tubes are placed between the two chambers. The tubes which are nearest to the fire—either the lowest rows or, if the arrangement is vertical, the inner rows—will become hotter than the upper or outer rows; and even

among the tubes which are equally close to the furnace some few will at times be hotter, from the state of the fires, than others, some of which may again possibly be abnormally cooled for the moment by the cold air entering when coal is put on. As a consequence the length of the tubes will vary, and this must cause a stress on the tube joints in the tube plates, because any tube which becomes shorter through cooling has a tendency to draw away from the tube plates, while a tube becoming longer by expansion tends to thrust itself into the plate. This to-and-fro stress on the plate causes the joints to work loose, and, as a consequence, under higher forcing and inefficient stoking heavy leakages suddenly develop in the tube plate. For this reason, in choosing the type of boiler the Oriolle, the Watt, the Babcock & Wilcox (fig. 7), and the Yarrow (fig. 9) also fell out of the running.

The fact that some of these boilers—just as in the case of the D'Allest boiler—have been and are still being fitted in war ships proves nothing as regards the correctness of their design. Under normal conditions, with moderate forcing and proper treatment, all these boilers remain efficient. On board ships of war, however, account has also to be taken of indifferent or bad treatment. Under such conditions the tubes of the Yarrow boilers on board English torpedo boats, as well as on board the Austrian torpedo boat *Viper*, have become bent, so that now so-called "distance pieces" have had to be fitted between the tubes to keep them straight. If such occurrences must be reckoned with, and such expedients have to be adopted because the constructions of the water-tube boiler is too rigid to admit of sufficient play to individual tubes, then it would seem that all boilers liable to a similar defect are hardly to be recommended for ships of war.

3. *Absolutely inaccessible boilers.*—Finally, all water-tube boilers whose tubes are absolutely inaccessible for cleaning had to be excluded as being quite unsuited to replace cylindrical and locomotive boilers in the navy. This disposed of such constructions as those of Perkins, Herreshoff, Palmer, Ward (1885 and 1888), Du Temple (1886), Hohenstein, and Bellis (1888). These boilers have been little used in war ships, and therefore claim no historical interest in this brief account. They will, however, be found illustrated and described, with particulars of their management, in the book on the Development of Ships' Engines in the last Ten Years, by Carl Busley, published in 1892.

4. *Types meriting consideration.*—After what has been said, the only kind of water-tube boilers remaining for consideration were either those in which the tubes are curved in the first instance, and which are not prevented from bending still more under expansion, without thereby causing a stress on their joints in the tube plates; or such boilers as only have their tubes fixed at one end in a water chamber, while the other end is free and admits of the tube expanding as necessary. If such a boiler should also have fairly large water and steam chambers, so as to obtain the advantages referred to at II, 1 and 4, without the disadvantages referred to at III, 1 and 2, becoming too prominent, then such a boiler could be profitably used in the navy, because it would be able to withstand high forcing without becoming leaky, and it would also bid fair, so far as leaking is concerned, to remain uninjured even if the stoking is poor.

The choice thus became restricted to the Reed, Normand (figs. 12 and 13), the Thornycroft (figs 14 to 16), and the Schulz (figs 17 and 18) among small-tube water-tube boilers, and among large-tube boilers to those of Niclausse (figs. 19 to 21) and Dürr (fig. 22). The last named could only be installed in a fore-and-aft direction, owing to the necessity for their tubes to be inclined horizontally in order to let the steam generated in them get away freely.

V.—FITTING OF GERMAN WAR SHIPS WITH WATER-TUBE BOILERS.

1. *Fitting of ships with Thornycroft, Schulz, and Dürr boilers.*—Of the boilers open to choice, those with small tubes were the lightest but difficult to inspect, while those

with large tubes were easy to inspect but complicated owing to the large number of doors. It was not easy to foresee which of these drawbacks would prove to be the most prejudicial on board ship, and the only course open was to build boilers of both types and to fit up some ships with one and others with the other type, leaving the final decision as to the type of boiler to be eventually selected for general use in the navy to depend upon the results obtained after the various systems had been thoroughly and practically tested. To fit up an experimental ship with various kinds of water-tube boilers was not admissible, because, on the one hand, any conclusions so arrived at as to the suitability of a given boiler for use on board ship would have been still open to question; while, on the other hand, the introduction of water-tube boilers could no longer be deferred if we were to compete with other countries, all of which had already adopted them, and thereby obtained increased speed in their ships together with a diminution in the weight of machinery. Nor, finally, could the construction of boilers for the new ships be postponed pending the result of the steam trials of the ships first fitted with water-tube boilers; hence it has come about that during the last six years a number of ships have been fitted with boilers of both kinds, small tube and large tube, without, up to the present, any definite conclusions having been arrived at as to the selection of the future type of water-tube boiler.

The trials in 1893 of the Thornycroft boilers fitted on board the English torpedo gunboat *Speedy* had already favorably drawn the attention of the German admiralty authorities toward small-tube boilers. Among the types of foreign design belonging to this class available for selection—the Reed, Normand, and Thornycroft—the last named was preferred, but an order was at the same time given for a Schulz boiler, because this latter seemed to promise certain advantages over the Thornycroft, which had already been tried.

As regards large-tube water-tube boilers these were first tried in 1895 on board the mining ship *Rhein*, for which the Dürr firm at Dusseldorf had constructed a boiler. The results obtained from this boiler were certainly hardly satisfactory; its efficiency proved to be no greater than a cylindrical boiler, it gave wet steam and was inaccessible for cleaning of the fire surfaces. On the other hand, steam trials which were carried out at Dusseldorf, in the summer of 1896, with a new and improved Dürr boiler gave such good results in every respect that it became possible to proceed with the construction of such boilers for use in war ships.

The following water-tube boilers have thus been ordered for the German navy during the last few years:

In 1894.—1, Thornycroft boilers for H. I. M. S. *Ægir*, and for torpedo boat S-74; 2, Schulz boilers for torpedo boat S-42.

In 1896.—1, Thornycroft boilers for torpedo boats S-82 to S-87, and for divisional torpedo boat D-10; 2, Thornycroft boilers in conjunction with cylindrical boilers for H. I. M. S. *Kaiser Friedrich III*; 3, Schulz boilers for torpedo boats G-88 and S-89; 4, Dürr boilers for H. I. M. S. *Baden*.

In 1897.—1, Thornycroft boilers for the gunboat *Iltis*; 2, Schulz boilers for H. I. M. S. *Württemberg*; 3, Dürr boilers for H. I. M. ships *Bayern* and *Vineta*.

In 1898.—1, Thornycroft boilers for the gunboats *Jaguar*, *Tiger*, and *Luchs*, for the small cruiser *Niobe*, for the armored coast defense ships *Hagen* and *Beowulf*, and for torpedo boats S-90 to S-101; 2, Schulz boilers for the small cruiser *Nymphe*; 3, Schulz boilers in conjunction with cylindrical boilers for H. I. M. ships *Fürst Bismarck*, *Kaiser Wilhelm II*, and *Kaiser Karl der Grosse*; 4, Dürr boilers for the large cruiser *Victoria Luise*, and for the armored ship *Sachsen*.

In 1899.—1, Thornycroft boilers in conjunction with cylindrical boilers for the battleship *Barbarossa*; 2, Schulz boilers for the small cruisers *Thetis*, *Ariadne*, *Medusa*, and *Amazone*, and for torpedo boats S-15, S-16, and S-37; 3, Schulz boilers in conjunction with cylindrical boilers for the battleships *Kaiser Wilhelm der Grosse*, *Wittelsbach*, and *E*.

In 1900.—1, Thornycroft boilers in conjunction with the cylindrical boilers for the battleship *D*; 2, Schulz boilers for gunboat *A*, and for the armored coast defense ships *Heimdall*, and *Hildebrand*; 3, Schulz boilers in conjunction with cylindrical boilers for the battleships *F* and *G*; 4, Dürr boilers for the large cruisers *Prinz Heinrich* and *B*.

On the one hand, it will thus be seen that the Thornycroft boilers are being gradually pushed aside by the Schulz boilers; and, on the other, that up to the present no decision has yet been come to to fit the large battleships with only water-tube boilers, but a mixed system of cylindrical and of small-tube water-tube boilers has been chosen for them. By this selection the boiler installations have been kept as light as when only cylindrical boilers were used, and yet, while account has been taken to some extent of the prejudice against water-tube boilers from their difficulty of management and their sensitiveness, the good points of both systems have been united in one and the same ship. To meet the case of defective condensers and impure feed water there are the relatively less susceptible cylindrical boilers, and to meet the need for raising steam quickly and forced draft there are the relatively less susceptible water-tube boilers. Water-tube boilers had at first, and still have, the reputation of burning more coal for the same power than cylindrical boilers, especially if running continuously over long distances. The large battleships, in which the need for saving weight was not of so pressing a nature as in the large cruisers and gunboats, with their combination of boilers, will consequently be enabled, when steaming at "ordinary" speed on long runs, to use the more economical cylindrical boilers.

If in course of time water-tube boilers should prove themselves to be as economical as cylindrical boilers, and also as entirely safe to use, if by any chance it might become necessary to feed them for some days with brackish water, there will no longer be any impediment to fitting large battleships exclusively with water-tube boilers, and it will be possible in this class of ship also to effect an important saving of weight.

The following are the names of the French war ships which either have been, or which still are, provided with Niclausse boilers: *Suffren*, *Marceau*, *Henri IV*, *Condé*, *Gueydon*, *Kléber*, *Requin*, *Friant*, *Fleurus*, *Téméraire*, *Zélée*, and *Décidée*.

The design of the Belleville boiler (figs. 23 and 24) does not comply with the requirements which have been laid down here at IV, 4^a. In this type of water-tube boilers the large tubes have one end attached to a steam collector; the other ends, however, are not arranged free, but open out into small water chambers which receive the feed water, and for this purpose are attached to a common tube. The tubes rest with the lowest back row of their junction boxes, on the boiler supports, by means of rollers, which, in a measure, form movable feet to the boiler. The water tubes themselves consist of straight tubes screwed into junction boxes and arranged in zig-zag order. There is thus the possibility of an expansion of the tubes if the cylindrical steam collector is somewhat lifted from the tube system. The circulation, moreover, necessitates having an exceptionally low level of water; the water capacity is therefore very small, and the disadvantages in connection with water-tube boilers referred to at III, 1, are especially marked in this boiler. Besides, this boiler could not be forced to any extent, and it had to be worked at a very high steam pressure, which was reduced in the pipes on its way to the engines by some five atmospheres, as otherwise the steam produced was hardly sufficiently dry.

2. *Trial of Niclausse and Belleville boilers.*—As will be seen from the foregoing list, speaking generally, two systems of water-tube boilers are in use in the German navy: First, the Thornycroft and the Improved Thornycroft—the latter being represented

^aCompare the report of the English water-tube boiler committee, which appeared on page 488 of the April number of the *Marine-Rundschau*, observing that this paragraph was already in the press when the report of the committee was published.

by the Schulz—and, second, the Dürr boilers. The fact that the other great naval powers showed a preference for other types caused the German naval authorities to experimentally fit up a few ships with these other types in order to be able to compare them with those which the German constructors considered to be the best kind of boilers. As a consequence the Schiff-und Maschinenbau-Aktien Gesellschaft Germania were ordered in the winter 1895–96 to supply H. I. M.'s large cruiser *Freya* with Niclausse boilers, and Belleville boilers for the large cruiser *Hertha* were ordered from the Stettiner Maschinenbau-Aktien Gesellschaft Vulcan. About a year later Niclausse boilers were ordered for the small cruiser *Gazelle* and Belleville boilers for the large cruiser *Hansa*.

In principle the design of the Niclausse boiler is similar to that of the Dürr boiler, but it differs considerably from the latter in matters of detail, and that, as will be seen later, not to its advantage. At that time, according to reports appearing in the French newspapers, such good results had been obtained from Niclausse boilers on board the protected cruiser *Friant* in France, and in England on board the torpedo gunboat *Seagull*, that the French Admiralty decided to equip quite a number of large ships with these boilers.

The following ships are, or were, fitted with Belleville boilers: In England—*Sharpshooter*, *Powerful*, *Terrible*, *Diadem*, *Arrogant*, *Furious*, *Gladiator*, *Andromeda*, *Europa*, *Niobe*, *Vindictive*, *Amphitrite*, *Argonaut*, *Ariadne*, *Spartiate*, *Hermes*, *Highflyer*, and *Hyacinth*. In France—*Isly*, *Descartes*, *Pothuau*, *Charlemagne*, *Pascal*, *Bouvet*, *Gaulois*, *Saint Louis*, and *Galilée*.

3. *Trial of Yarrow and Normand boilers.*—In order to leave nothing uninvestigated the German Admiralty, in 1896 and in 1899 gave orders for torpedo boat S 32 to be fitted with Yarrow boilers and for divisional torpedo boat D 3 to be fitted with Normand boilers.

VI.—EXPERIENCES WITH WATER-TUBE BOILERS.

1. *With small-tube boilers.*—The trials of the Thornycroft boilers on board H. I. M. S. *Ægir* and on board torpedo boats S-82 to S-87, and also of the Schulz boilers in torpedo boats S-42, G-88, and G-89 were on the whole satisfactory, and especially demonstrated the superiority of this boiler over the locomotive boilers with which the ships of the *Ægir* class and the torpedo boats had hitherto been fitted, in so far that the boilers remained in good condition under any kind of forcing and treatment of the fires. The fear that the small tubes, when impure water was used, would become obstructed and then get red hot and burst was, however, justified. As a water-tube in a Dürr boiler on board H. I. M. S. *Baden* also got foul with scale and grease, thereby causing it to get red hot at a weak place and burst, orders were issued that all water-tube boilers should be filled and fed with distilled water only, and other measures were adopted to prevent the accumulation of harmful greasy deposits on the inner surfaces of the tubes. The evaporators for all ships fitted with water-tube boilers were made of such dimensions that, under any circumstances, distilled water only could be used for boiler "make-up" feed. Feed-water filters were also inserted in the delivery pipes of the air pumps, and into the delivery pipes of the feed pumps, and measures were likewise taken to keep soda constantly mixed with the feed water. Since the introduction of these expedients no bursting of tubes has taken place either in the small-tube water-tube boilers or in the Dürr boilers.

The fact that the small water chambers serve as bottom-tube plates to the outer rows of tubes at first greatly impeded the cleaning of the insides of the tubes of the "Daring" type of Thornycroft boilers. In the original Thornycroft boilers fitted on board divisional torpedo boat D-10 their internal diameter was only 6 inches; the diameter of these water chambers has lately been increased to between 15 and 17½ inches, so that they can now be easily examined.

The cleaning of the insides of the small water tubes was further greatly impeded

by the ends of the tubes being tapered to a less diameter than the body of the tubes, in order not to weaken the tubes' plates too much and to enable the tubes to lie closer. This is now no longer the case, and the following method of cleaning has accordingly been laid down: As a rule, a frequent scouring of the boiler with soda and blowing out the soda solution, which carries with it the loosened grease and dirt, is sufficient; after which the tubes are washed out from the steam collector with water under pressure. Once every year, however, the same special inspection and thorough inner cleaning as is prescribed for cylindrical and locomotive boilers is to be undertaken, the instruments shown in figs. 25 to 27 being used for the purpose. These consist of small steel brushes of the shape shown in fig. 25, and scrapers made of watch springs (fig. 26), which are drawn through the tubes by steel-wire cords—using for the purpose the friction roller arrangement shown in fig. 27—and so scrape off the deposits adhering to the inner walls of the tubes. This cleaning is carried out by one petty officer and five stokers in two hundred hours—that is to say, twenty days of ten working hours—and is sufficient, so far as the experience hitherto obtained with forced draft in torpedo boats goes to show, to prevent any irregularities in the working of the boilers. Less thorough cleanings have been carried out on board the *Württemberg* after seven hundred hours' steaming in eight days.

On board the gunboats *Illis* and *Jaguar* also—the *Illis* has already been in commission for more than two years, and for most of the time under unfavorable conditions—irregularities in working have only been reported in a single case, where it was clearly shown that the cause was attributable to want of water; in this case in the boiler concerned the joints of the tubes in the steam-collector tube plates leaked.

One defect noted in the Thornycroft boilers on board torpedo boats S-82 to S-87 was attributable to the short distance which the hot gases pass over among the tube rests on the way from the grate to the uptake. Under forced draft the flames shoot up above the short funnels, and the boats consequently are visible at long distances by night. If the funnels are raised, the flames no longer issue from them, but the uptakes become so heated that economical working can not be expected. In the Schulz boilers, which are really in essentials improved Thornycroft and Normand boilers, this inconvenience is obviated by arranging the tubes in single rows, and so making them to serve as guide walls to the hot gases, which are thus made to travel such a long distance among the tube nests that they give up sufficient heat to the water as to prevent the formation of flames in the funnels, while also insuring good utilization of the gases. As regards coal consumption, when traveling at a speed of 12 knots, the consumption on board torpedo boat S-83 was 2.2 pounds and on board divisional torpedo boat D-10 2.64 pounds per I. H. P. per hour, both being fitted with Thornycroft boilers; on the other hand, the consumption on board G-88, which is fitted with Schulz boilers, was only 1.59 pounds, or just 28 per cent less than the amount of coal consumed on the similar sized torpedo boat S-83. The heat registered in the funnels of the Thornycroft boilers was 700° C. (1,292° F.) as against from 412° to 425° C. (773° to 797° F.) in the funnels of the Schulz boilers.

The Thornycroft and also the first Schulz boilers had the disadvantage that when preserved full of water, which is generally advisable when the boats are being kept ready for service, all the air could not be expelled from the upper bends of the water tubes. In the Thornycroft boilers, where the tubes discharge above the water level in the steam collector, this inconvenience can not be remedied. The Schulz boilers, however, are now so constructed that the highest part of the upper bends in the tubes do not lie higher than the openings into the steam collector, and this arrangement consequently obviates the inconvenience in question.

The fear at one time expressed that the water circulation in the tubes when working at a moderate rate would be so small that some of the tubes would become red hot and burn through has hitherto proved groundless. The tubes put into the Thornycroft boilers of H. I. M. S. *Egir* four years ago, even the top ones lying near-

est the steam collector, have their ends, which are expanded in the tube plate, still in good condition. These ends are, however, rusted inside, and this must be attributed principally to the galvanic action arising from the brass baffle plates originally fitted and from the bronze feed regulators arranged inside the steam collectors with the copper feed and steam pipes. The harmful effects of galvanic action on the steam collector and generating tubes will in future be obviated by making these fittings of iron and steel.

At first the tubes in the boilers of torpedo boats S-74 and S-82 to S-87 suffered rapid deterioration from the outside, but since greater attention has been paid to keeping the ends of the tubes dry, especially the lower ones lying next to the water chambers, which become covered with dirt, the tubes have remained sound. On board the *Ægir*, the zincking on the outside of the tubes has worn off completely after four years' service, but the thickness of the tubes has not perceptibly diminished. These tubes in the Thornycroft boilers of the *Ægir*, in consequence of this diminution in the strength of the upper short ends, are now to be renewed; as, however, the tubes are otherwise sound, the long tubes are to have their ends cut, and, after rezincking, will be replaced and again used as shorter tubes, so that out of 3,300 tubes only 900 require to be replaced. This repair is necessary in order to insure the boiler working reliably for some years, but in the event of war the tubes could have been left in the boiler in their present condition without any danger.

If the same experience obtains as to the life of the tubes in the latest Schulz boilers, it may be assumed that these boilers will require retubing every four years; it is, however, probable that by utilizing the experience acquired in the meantime the lives of these boilers will be considerably prolonged. In any case, it should not be overlooked that the tubes in cylindrical and locomotive boilers require to be renewed after about five years' wear.

Speaking roughly, the probable serviceableness of the latest Schulz boilers should not be judged from the experience gained with the first, and in many respects imperfect, boilers of this and of the original Thornycroft types. In any case, however, the duration of life of the improved Schulz boilers is as yet unknown, and the distrust of the opponents of small-tube boilers to the durability of the tubes in this boiler is explicable if they reckon on having to meet the enemy with ships whose tubes are from four to five years old. The thickness of these tubes, as with all other water and fire tubes, can only be ascertained by taking out and cutting up certain specimen tubes. This test is applied once a year, the same as it is to cylindrical and locomotive boilers which have iron tubes, under the instructions for the inspection of boilers already referred to, and so far this inspection has sufficed to prevent the tubes bursting after becoming thin. It must be remembered that the stress on the material of the small water tubes is only from 0.48 to 0.65 kilogram per square millimeter (682.7 to 924.5 pounds per square inch), which is only about one-fiftieth of the ultimate strength of 34 kilograms per square millimeter. Any ordinary wasting of the material of the tubes caused by rust and wear can therefore hardly bring about the bursting of a tube. The only things detrimental to the durability of small tubes is the scale developed on their inner surfaces, as referred to at III, 3. It would therefore be desirable if a system of inspection could be introduced which would admit of its being possible to ascertain whether the inner surfaces are clean enough to obviate any anxiety being felt in regard to the possibility of the tubes becoming choked when the boilers are worked for prolonged periods. Up till now scale alone has not caused any bursting of small tubes, this having only taken place from a complete stoppage in the tubes; this is easily explained by the fact that even with the reduction of conductivity to heat, the tubes do not become so hot that their diminished strength renders them incapable of withstanding the comparatively small strain thrown upon them. Only complete cessation of the water circulation apparently brings about this excessive heating of the tubes. An

inspection of the inner heating surfaces of the small tubes in the Thornycroft and Schulz boilers is, however, only possible by passing a steel-wire brush through each separate tube, which is obviously an inconvenient and lengthy proceeding; if the brush can pass, then it is clear that there is no great fouling or formation of scale, but beyond this nothing further is conclusively proved. Time alone will show whether the formation of scale on the inner surfaces of the tubes will still continue when using distilled water only for the feed, and the measures now adopted for filtering the feed water and keeping it alkaline with soda. Up to the present such has not been the case; but account will always have to be taken of the possibility of leaky condensers and consequent brackishness of the boiler water. If, even with leaky condensers, injurious deposits of scale do not take place, then the inspection of the inside of the curved water tubes by viewing can be dispensed with, and the examination of the tubes can be limited to the yearly special survey and to cutting up certain tubes as samples; in such case, these boilers could then be considered as quite safe for working. So long, however, as this has not been definitely established the engineer in charge would do well, if any defect or leak should manifest itself in the condensers, to frequently change the boiler water and to clean and refill the boilers not in use. Under such circumstances it would be inadvisable to undertake a long run at high speed with all the boilers working, until the defect in the condensers had been remedied.

The opponents of small-tube water-tube boilers specially put forward the assertion that the captain can not be responsible for the engineers having the boilers clean at any moment, and consequently in a state of readiness for war. On this point it is to be observed that locomotive boilers which the engineers in charge had considered to be sufficiently clean became completely unworkable for a considerable time in a trip between Wilhelmshaven and Kiel owing to leakage at the tube plates, which, on a closer inspection of the boiler being made by removing some of the tubes, proved to be due to the ends of the tubes being covered with a thick crust of salt close to the tube plates. This incident occurred some five years ago on board H. I. M. S. *Beowulf*. The case, however, in which cylindrical boilers became unworkable because of their tubes becoming incrustated with salt or scale are not infrequent. It may be conceded that cylindrical boilers do not become dangerously oversalted as quickly as water-tube boilers.

The cleaning of the exterior of water tubes is carried out by means of compressed air from the air blowers, and is no longer attended with difficulties.

2. *With Dürr boilers.*—The experience with Dürr boilers has also proved so far successful that the boilers have shown themselves to be unaffected by heavy forcing and to sudden changes in the draft. The solitary case of a tube bursting through extensive fouling has already been mentioned at VI, 1. Dürr boilers are heavier than small-tube water-tube boilers, but they possess an advantage over the latter type in the ease with which the cleanliness of the inner surfaces of the tubes can be ascertained. It is true, however, that in respect of this inspection, if it is to extend to all the tubes, an enormous number of doors, one at least for each tube, have to be opened out and closed again, which necessarily takes up much time and labor, more especially so as the inner tube of each generating tube has to be taken out and replaced. Practical experience has, however, shown that it is principally the lowest tubes which foul, and, as a rule, therefore, it is only necessary to examine the three lowest rows of tubes, and if these are found to be clean the upper rows need not be examined. But in order to carry out a thorough cleaning of the boiler the whole of the tube-hole doors, both at the front and back, must be opened, and this means for a ship like the large cruiser *Prinz Heinrich*, which has 14 boilers, with 574 water tubes in each, the removal of $2 \times 14 \times 574 = 16,072$ doors. An extensive cleaning of the boilers takes place after each steaming period of from seven hundred to one thousand hours. On such occasions all the tube-hole doors are opened and each outer tube is scraped and

washed. All the inner tubes are also swept with steel brushes and washed out inside. Such a cleaning, necessitating the opening up, cleaning, and closing again of the boiler, takes up the time of 2 petty officers and 10 stokers for thirty-eight hours for each boiler, which makes four days of ten working hours for each.

The original construction of the back-tube stoppers, which is very solid and absolutely safe, greatly hindered the work of cleaning, because, as will be seen from fig. 28, the inner conical plug had to be pulled out to the front of the boiler, and after the tube was cleaned the plug had to be pushed in again to the back end of the tube. Recently, however, the back closing arrangement has taken the form of a cap nut, as shown in fig. 29. This closing arrangement having been experimentally tried on some of the tubes in the *Victoria Luise* and *Sachsen*, and having been found to answer, the tubes in the Dürr boilers of the *Prinz Heinrich* and of the large cruiser "B" are closed with the new cap nuts. The time required for cleaning the boilers will be materially shortened by this improvement. These cap nuts are made of wrought bronze of great strength, and have V-section ridges turned on the face for making the joint instead of the conical threads used with the cap nuts of the Nielausse boilers.

In the later Dürr boilers the water chambers extend farther below the lowest row of tubes and form a sediment chamber; it may be assumed, therefore, that the tubes will in future be cleaner and that the intervals between the thorough cleanings of the boilers will be longer. Presumably, also, ships, even on foreign service, fitted with the latter boilers will only need to have their boilers thoroughly cleaned twice a year, provided that the condensers do not leak; as bearing upon this, the condensers will in future perhaps prove more reliable, now that their tubes are being made of stronger material. If the condensers are leaky and the water becomes brackish in consequence, the boilers prime heavily, especially if the water at the same time contains soda. However, these boilers have not proved themselves to be so greatly affected by being fed by brackish water as was feared by many persons. On board the *Sachsen* a Dürr boiler was at work continuously on harbor service for some days with feed water containing 10 per cent of salt without any of the tubes becoming heated. Salt scale, especially at the back ends of the lowest water tubes, 2 millimeters (0.079 inch) thick, which has been formed in this way, has had no injurious effect. The stress on the material is also relatively small in the tubes of these boilers, and the margin of safety is high.

Great care must be taken in preserving the inner tubes, which are made of quite thin mild steel plates, and the superheater tubes. The boilers should either be preserved by the wet method, i. e., by keeping them quite full of water, or by the dry method, when they are not in use. If by chance the boiler water is blown out through the blow-off cock, and the tubes are not at the same time emptied—as happened when the *Victoria Luise* was first put out of commission—the upper ends of the inner tubes are deprived of water, and, being surrounded with damp air, quickly rust. At first the tubes used to be emptied by syphoning from the front; but lately the practice on board the *Sachsen* has been to loosen the back conical tube stopper. The new style of closing by means of cap nuts will still further facilitate emptying the tubes. In the opinion of the captain of the *Sachsen*, the introduction of this closing arrangement will enable a complete change of water to be effected in a Dürr boiler in from three to four hours. The thin tubes in the superheater, similarly to the inner tubes, are liable to be injuriously affected by damp or air unless the boiler after ceasing to work is either kept quite full or quite dry. Hitherto the system of design made it difficult to completely fill the superheater tubes, but in the boilers now being built this inconvenience is being remedied by providing means of exhausting the air from them.

The back walls of the Dürr boilers necessitated constant repairs. The tubes which are fixed in the tube plates of the water chamber by thickened and skewed cones lie

with their back ends free in a latticed wall, the openings in which serve at the same time to help the cleaning of the tubes, which is carried out by means of forced draft from the boiler room. These openings are closed with plates lined with asbestos pulp, which are fastened to the lattice work by pins and cotters. These plates, however, become warped and often burnt by the heat, so that labor is entailed in straightening or replacing them. The side-wall casings, as in all water-tube boilers, also suffer from the heat, because the outer rows of tubes, which form the external wall of the furnace, can never be kept quite tight, and yet all these casing plates have to be as thin as possible to keep down the weight of the boilers. The cleaning of the fire side of the outer tubes, which at first occasioned trouble, can now be carried out in a simple manner, even while the boiler is working, by forcing air, under pressure, through from the ventilating fans, with the ash-pit doors closed and the furnace doors open. The air passing over the fire into the furnace blows most of the soot which is lying on the tubes out through the funnels. This soot has been the principal cause of the economy of the Dürr boilers having hitherto, when running for long distances, been less apparent than it was on the official acceptance trials. It may, however, be taken for granted that this inconvenience will not in future make itself felt to the same extent if the furnaces, when making long runs, have air blown through them. When a thorough cleaning is to be made, with the boilers cold, the air, as already remarked, will be blown through the lattice work into the tube nests, the back-casing plates being removed singly for the purpose as necessary. With a view to more effectually removing the soot which collects on the baffle plates used for directing the course of the gases, a shaking arrangement has lately been fitted to the baffles. The Dürr boilers have thus either been, or are being, improved as a result of the experience gained from their working on board ship. At first the consensus of opinion was undoubtedly against these boilers, because so much work was occasioned in the handling and keeping in order of the numerous doors, and because of the constant exertion entailed upon the boiler-room personnel. These boilers, however, should not be judged by the experience of the first types alone, but judgment on them should be suspended until experience has been obtained with the later types. It may be said, however, that even the present opponents of this system appreciate its advantages in regard to facility of inspection, and do not counsel its abandonment. It has recently been decided to build more of these boilers, and that the large cruiser about to be constructed to replace the *König Wilhelm* should be fitted with Dürr boilers.

3. *With Niclausse boilers.*—The experience of the German navy with Niclausse boilers has so far been very unsatisfactory. In October, 1898, the small cruiser *Gazelle* and the large cruiser *Freya*, both of which are fitted with Niclausse boilers, made their first trial trips, and it was not until April, 1901, that the *Gazelle* could be commissioned with serviceable boilers, and that the *Freya* could continue her interrupted trials. The interval was taken up in making repeated alterations in the boilers.

The most serious defect in this boiler is attributable to the large use made of malleable cast iron, a material which should be altogether excluded in boiler construction. This material is cast iron, to which greater strength than is possessed by ordinary cast iron is imparted by heating it without air in a layer of coal dust. The resulting material is not so brittle as cast iron, but is not equal in tenacity to wrought iron, and already, in consequence of the strains set up in cooling after the casting, easily bursts.

Immediately after the first trials cracks were noticed in the malleable cast-iron headers and lanterns (see figs. 21, 30, and 31). The cracks in the headers, which were in the diaphragm and extended from one tube hole to another, were not dangerous; those which ran in the direction of the outer walls could, for the most part, be drilled and made harmless, so that the water chambers could, at least for a time, be considered as safe to work. The lanterns, however, were all replaced by others made of mild steel (compare figs. 32 and 34), because the complete fracture of both

webs of a lantern would be followed by the breaking off of the dog of the tube-hole door—at that time still made of malleable cast iron—which would have dangerously imperiled the lives of the stokers in the boiler room.

The long-drawn-out negotiations between the Admiralty and the contractors for the engines, the Schiff- und Maschinenbau-Aktien-Gesellschaft Germania, and between this latter company and the patentees of the boiler, the Niclausse firm in Paris, as well as the preparation of a large number of new lanterns, and fitting them in the boilers took a very long time; finally, however, when, after an interval of two years, the *Freya* was able to recommence her trials one of the outer tubes burst and the back cap nut of another outer tube stripped off. On inspecting the boiler a large number of tubes were found to be considerably bent upward, and, from the appearance of the tubes, it was evident that they had been red-hot. The only reason for the tubes getting red-hot must have been from want of water, but as the gauge glasses during the run indicated a sufficiency of water the deficiency in the tubes must have been due to defective circulation. This view was borne out by the fact that during the trial run the ship was considerably out of trim, and that the greatest bending in the tubes and the bursts which occurred in two separate boilers took place in those boilers where tubes had assumed a more horizontal position than their customary angle of inclination owing to the ship's want of trim.

On examining the front part of the headers it was seen that in some cases the ports in the lanterns between the webs and through the holders of the inner tubes were somewhat small, and in others that the lanterns had too great an amount of play in the diaphragm plate in the headers, so that a portion of the water entered the back part of the headers without passing through the inner tubes. The construction of the lanterns, as may be seen from figs. 32 and 33, did not admit of a further weakening of the webs; it was to be assumed, however, that the ports in the lanterns would be large enough if the lanterns were arranged in the headers in such a way that ports in the lantern and the holder for the inner tube were turned so as to lie up and down, and if the play in the diaphragm were reduced to a minimum by a thickening of the lantern at this point. From a trial made during a six hours' run with a boiler altered in this way in H. I. M. S. *Freya*, with the ship properly trimmed and with forced fires—i. e., with a consumption of 170 kilograms of coal per square meter (34.8 pounds per square foot) of grate area per hour, this surmise was proved to be correct, and the whole of the boilers in the *Freya* and *Gazelle* were altered accordingly. The tubes in the Niclausse boilers have an inclination of 6 degrees to the horizontal; in the trial run on board the *Freya*, when the accident took place, this inclination was diminished to about 5 degrees. At the time of the accident the webs for the most part were arranged up and down and the holders for the inner tubes lay below and so covered the lower ports underneath. In the trial referred to, the webs and holders were arranged as shown in fig. 32. With this arrangement the circulation of the water proved sufficient even under unfavorable trimming of the ship. As was shown by the experiments carried out by Professor Gutermuth with the Dürr boiler, the circulation of water, when the tubes have as small an inclination as only 1 degree to the horizontal, is sufficient to prevent the tubes from getting red-hot. Moreover, it should be borne in mind that the flow of water from the water chamber into the inner tubes is much less impeded in the Dürr boiler than in the Niclausse boiler. It goes without saying that it is an essential requirement in ships' boilers that they should be able to stand changes in the trim of the ship without ill effects.

Similar accidents to the one which occurred on board the *Freya* have also taken place in the Italian armored cruiser *Garibaldi*, which is fitted with Niclausse boilers. The French press have not allowed any accidents to Niclausse boilers to become known; it may, however, be surmised that such must also have occurred on board French war ships, since Niclausse has given up the less reliable, but cheaper, malle-

able cast iron, and now fits his boilers exclusively with the much more expensive mild steel (flusseisen.)

It should further be mentioned that in some pressure trials of water tubes, carried out after the substitution of mild-steel lanterns for the malleable cast-iron lanterns, a large number of the cap nuts, also made out of malleable cast iron, used for closing the back ends of the tubes, burst; it is probable that they were screwed up on the conical threads with too much force. In consequence of this experience all the cap nuts were replaced with others of mild steel.

Even after making these alterations, the design of the Niclausse boilers still gives rise to a certain amount of danger in so far that some amount of stress is present, which tends to lift the tubes from their seatings in the headers and to force them out of the headers toward the firing space. Under normal conditions this stress is taken up by the friction in the conical seatings, and by the dogs on the front walls of the water chambers, each of which holds two tube doors, and which are secured to the malleable cast-iron headers by means of studs and nuts. If at any time, however, any of the tubes show signs of leakage, it is very convenient for the stokers to screw down the nuts on the studs of the dogs and thereby to put a stress on the tubes, which may easily cause a stud to draw out of the thread in the malleable cast iron; if this occurs, then the two tubes concerned are only retained in the boiler by the friction in the conical seatings. In the Dürr boiler the tubes are forced against the conical seatings by the pressure of the water, and the hand-hole doors in the front tube plate are absolutely secure from any danger of flying out because the openings in the tube plates, into which they bed, are coned, with the large end inside.

This element of safety (see fig. 34) serves, to some extent, as a set-off to the difficulty experienced in removing and replacing the hand-hole doors.

How the fine-cut threads are likely to last time alone will show. In Germany, such threads have hitherto only been used in telescope making, but never in boiler construction. On board H. I. M. S. *Gazelle*, where some of the fittings of the blow-off cocks on the front of the water chambers are screwed with similar fine threads, they have hitherto leaked continually.

The attachment of the headers to the steam collector also can hardly be considered as being solid; some of the studs broke off, even when the boilers were being erected.

After these experiences, and after a critical examination of the details of design, there is no reason why we should exchange the proved solid construction of the Dürr boiler for that of the Niclausse boiler, especially when all that has been adduced against the Dürr boiler, at VI, 2, is also to be met with in the Niclausse boiler, and when the details of design in which the Niclausse boilers differ from the Dürr boilers compare unfavorably with similar details in the Dürr boiler.

4. *With Belleville boilers.*—The Belleville boilers without economizers, as fitted on board H. I. M. ships *Hertha* and *Hansa*, have the reputation of being very uneconomical, and it is partly for this reason that this type of boiler is being given up in England. The coal consumption in the acceptance trials of the *Hertha* and *Hansa* was, on the average, 1.98 pounds per I. P. H., both for the continuous full-power trials and for the ordinary speed trials, and consequently does not compare unfavorably with many of the runs made with cylindrical and locomotive boilers, or with other types of water-tube boilers; especially considering the moderate forcing of the boilers with a coal consumption of from 16.69 to 17.56 pounds per square foot of grate area per hour for the full-power trials, and of from 8.35 to 8.6 pounds for the ordinary speed trials.

When H. I. M. S. *Hertha* went out to the China station the mean coal consumption of ten continuous hours at ordinary speed was 13.5 pounds per square foot of grate surface per hour, which is equal to a consumption of 2.9 pounds per I. P. H. per hour; on some runs, with 4,600 I. P. H., the consumption was 2.8 pounds per

I. P. H. On the other hand, from a report sent in by the captain of the *Hertha*, it appears that on a previous occasion, after the boilers had been thoroughly cleaned and the engines had been overhauled, during a twenty-four hours' run at ordinary speed and with a coal consumption per hour of 11.67 pounds per square foot of grate surface, the consumption per I. H. P. was only 1.79 pounds per hour. According to the newspapers the English cruiser *Europa* was said to have consumed during her contractors' trials, when her boilers were new and clean, only 1.54 pounds of coal per I. H. P. per hour, whereas later, when going at ordinary speed, the consumption rose to 4.85 pounds per I. H. P. It appears, therefore, as if these boilers foul very much when working continuously, and consequently become uneconomical.

During the construction of the boilers for the *Hertha* and *Hansa* much stress was laid by the makers in having Serve tubes for the lowest rows, which are those most exposed to the fire. Such tubes, however, at that time could only be made by welding, and three of them burst at the welds when the boilers were being worked. Even with only three burst tubes out of a total of 792 welded tubes—barely 0.4 per cent—the possibility of further bursts taking place, entailing probable injury to the stokers, was considered too serious a risk to be incurred, hence the whole of the Serve tubes have now been replaced by ordinary seamless tubes. Although the effect of this alteration was to diminish the steaming efficiency of the boilers, it increased the safety of working.

Similar unfortunate experiences attended the working of Belleville boilers in the English navy; here also the welded Serve tubes have been replaced by seamless tubes.

Allusion has already been made at V, 2, to the disadvantage possessed by these boilers as compared with other water-tube boilers by reason of their unusually small water capacity, and the consequent introduction of reducing valves in the steam pipes. These reducing valves have often given rise to trouble when steaming. Moreover, the use of high-pressure steam necessitates comparatively great strength in the materials of the steam pipes, and consequently requires heavy pipes because the reducing valves are not reliable, and the strength of the pipes even beyond the reducing valves requires to be calculated for the higher steam pressure.

Above all, however, these boilers have been found to suffer considerably if used with leaky condensers. In spite of their being only fed with distilled water, thick deposits of salt have frequently been found to take place as the result of any defect in the condensers; these deposits especially occur in the upper tubes, which at times become almost completely choked. In order to prevent explosions from taking place from this cause, Belleville places small fusible plugs of lead in the junction boxes, which melt as soon as the tubes become hot through any obstruction of the circulation. The hissing of the steam issuing from the small holes thus made in the boxes warns the stokers of the coming danger; thereupon the fires are drawn and the boiler, after becoming cool, is examined and cleaned. Such occurrences often took place on board the *Hertha* and *Hansa*, and it is solely owing to the extraordinary care and vigilance of the engine-room complements of these ships that, beyond the bursting of the Serve tubes already referred to, more serious accidents have hitherto been avoided.

Belleville boilers can be inspected, but only by opening a large number of doors which give rise to leakages and repairs. Complaints, as a consequence, are often heard of the great amount of trouble and labor caused to the personnel during the process of inspecting, cleaning, and repairing these boilers. Their peculiarity of producing wet steam has led to the adoption of a very extensive system of baffle plates, which take up the whole of the steam collector and have to be removed whenever the collector is inspected. The baffle plates suffer considerably by rusting, and have also been quite destroyed by the action of the wet stream of steam impinging on them. A large number of the plates have already, as a consequence, had to be renewed.

Finally, the shortness of the flame circuit between the tubes has proved very inconvenient. The heated gases enter the uptakes and funnels at a very high temperature and heat them excessively. On board H. I. M. S. *Hertha* the funnels gradually collapsed, necessitating lengthy repairs and the adoption of specially arranged stays before they could be made serviceable again.

Taking everything into account, there are no grounds for again bringing this system of boiler into use in the German navy.

5. *With Yarrow boilers.*—I have been unable to obtain any details as to the experience with the two Yarrow boilers fitted on board torpedo boat S32. It has, however, been proved that they are very uneconomical; and as early as 1898, that is to say, after they had only been two years in commission, 145 tubes had to be replaced in each boiler, which necessitated the boilers being taken out of the boat, as otherwise the water chambers were inaccessible. Any further employment of this system of boilers for torpedo boats is considered as inadmissible.

VII.—ECONOMY OF THE VARIOUS SYSTEMS.

It is very difficult to decide on the exact economy of any boiler system. If, in order to ascertain it, experiments are carried out on shore with any individual type its efficiency will be better or worse entirely according to the skill of the stokers. For instance, recently during some experiments carried out on shore with a Belleville test boiler fired by an ordinary well-trained stoker, such as is generally available, 1 pound of coal converted 7.84 pounds of water at 0° C. into steam at 100° C., whereas with a specially skillful stoker, supplied by the makers of the boiler, the quantity of water evaporated was 8.836 pounds; in both cases 35.8 pounds of the same coal were burned per square foot of grate surface per hour, but in the second experiment the dampers were used at each firing up, and the furnace doors were never kept open longer than ten seconds. It is clear that similar results could never be attained on board ship where a large number of boilers would be simultaneously at work.

Supposing the amount of coal burned on board ship were to be measured and compared with the I. H. P. developed by the engines during the period of trial, the result would be appreciably influenced by the economy of the engines, by possible leakages from joints and stuffing boxes, and by the not easily ascertainable consumption of the auxiliary engines, especially of the steam steering engines.

Reliable results could only be obtained by measurements of the feed water; such measurements, however, are very difficult to carry out, because serviceable water meters are not inserted in the feed pipes, and such experiments could therefore seldom be made.

The results obtained on trial runs, apart from those for ascertaining the economy of the boiler, would, to a certain extent, be free from objections if the work done by the boilers was in all cases the same. This, as will be seen from the tabulated results given in Appendix I, is, however, never the case.

Even for sister ships which are both fitted with the same types of boiler ordered from different makers, the details of construction which have an effect upon the economy differ considerably, so that sometimes the difference in the calorific results between two boiler installations of one and the same system are greater than the difference between installations of quite different systems. A striking instance of this is to be seen in the two Dürr installations on board the *Baden* and *Bayern*.

The coal consumption during the trials of H. I. M. gunboat *Tiger* must be left out of consideration, because the slide-valve packing rings used during these trials have from the experience of the gunboat *Luchs*, built at the same yard, been proved to let steam pass. Besides, when the mean values obtained from the various trial runs with the different systems of boilers are compared, it is found that the difference in

the coal consumption per I. H. P. per hour amounts to about 13 per cent for ordinary speed and 19 per cent for continuous full speed.

The following table gives the coal consumption per I. H. P. per hour for the work done by the boiler as stated:

At ordinary speed.

Type of boiler.	Coal consumption per square foot of grate surface per hour.	Coal consumption per I. H. P. per hour.
	Pounds.	Pounds.
Schulz	16.7	1.96
Niclausse	12.4	1.96
Cylindrical	11.5	2.01
Belleville	8.12	2.01
Dürr	14.0	2.06
Thornycroft	17.5	2.21
Locomotive	14.9	2.23

AT MAXIMUM CONTINUOUS SPEED.

Thornycroft	23.6	1.79
Niclausse	15.4	1.81
Cylindrical and Schulz	14.0 and 20.7	1.82
Cylindrical and Thornycroft	14.1 and 21.9	1.84
Cylindrical	17.4	1.86
Dürr	19.7	1.91
Locomotive	28.2	1.98
Belleville	17.1	2.01
Schulz	26.9	2.18

Apart from the fact that these two tables show discrepancies in the order of sequence—e.g., the Schulz boilers in the trial runs at ordinary speed occupy the first place, while they take nearly the last place in the maximum continuous speed runs—it will be seen on reference to the tables in Appendix I that some of the boiler systems have both very low and very high coal consumptions, hence the statement seems justified that the boilers of all these systems, if properly proportioned and properly handled, pretty well all work with the same economy.

This seems to be the case as regards the cylindrical, Schulz, Thornycroft, and Dürr boilers, with which the following very favorable coal consumptions have in certain instances been obtained:

Type of boiler.	Vessel.	Pounds per I. H. P. per hour.
Cylindrical	Wörth	1.58
Schulz	Nymphe	1.67
Thornycroft	Iltis	1.60
Dürr	Bayern	1.56

As a rule the results of trial runs available are too few for deductions to be drawn from them as to which type of boiler is the best on the score of economy, for it is impossible from two such entirely different results as were given in the ordinary speed trials of the *Württemberg* and *Nymphe*—which vary some 35 per cent from each other—to take the arithmetical mean, and to use the figure so obtained as a basis from which to judge the economy of the system. It may be taken for granted, however, that

the results of the trials so far carried out go to show that equally good results can be obtained from the Schulz and Dürr boilers as from cylindrical boilers.

It was at first freely asserted that water-tube boilers under continuous steaming would be less economical than cylindrical boilers. But this assertion is not borne out by the coal consumed by the First Squadron during a trip to Lisbon in the summer of 1899. In the following table the coal consumption of the ships forming this squadron is given, first for their official acceptance trials, and, secondly, for the voyage referred to at 9 and 12.5 knot speeds:

Name of ship.	Official acceptance trials (pounds of coal per hour).		Voyage to Lisbon.			
			At 9 knots (pounds of coal per hour).		At 12.5 knots (pounds of coal per hour).	
	Per square foot of grate.	Per horse-power.	Per square foot of grate.	Per horse-power.	Per square foot of grate.	Per horse-power.
<i>1. Cylindrical boilers.</i>						
Brandenburg	12.0	1.64	10.9	2.8	16.64	2.205
Weissenburg	12.3	1.74	11	3.13	16.67	2.266
Kurfürst Friedrich Wilhelm.	12.9	1.83	9.7	2.8	15.28	2.39
Wörth.....	9.7	1.58	10.3	3.24	14.44	2.081
Mean	11.7	1.70	10.46	2.998	15.76	2.237
<i>2. Dürr boilers.</i>						
Baden	15	2.32	18.2	4.056	20.48	2.908
Bayern	14	1.97	15.87	3.064	22.32	2.359
Mean	14.5	2.14	17	3.56	21.4	2.632
<i>3. Thornycroft boilers.</i>						
Egir.....	10.4	2.15	18.2	3.263	25	2.685

The coal consumption per I. H. P. has consequently increased on the average as follows:

Type of boiler.	At 9 knots.	At 12.5 knots.
	<i>Per cent.</i>	<i>Per cent.</i>
Cylindrical	^a 78.7	^a 33.4
Dürr	^a 67.5	^a 24.4
Thornycroft.....	^a 53.6	^a 26.3

^a About.

That is to say, the depreciation in economy, as compared with the official acceptance trials, has been greater with the cylindrical boilers than with the water-tube boilers. If the mean values are considered, the coal consumption per I. H. P. is actually greater with water-tube boilers than with cylindrical boilers, because only two sets of Dürr boilers are used in the comparison, one of which—in the *Baden*, which were the first of the system to be used on board a war ship—from the outset proved themselves to be uneconomical, and because among the small-tube water-tube boilers only one Thornycroft boiler comes into the comparison.

The coal consumption per I. H. P. of the *Bayern*, on the other hand, for continuous steaming is approximately the same as in the ships with cylindrical boilers, viz, 3.064 pounds, as against the mean for the four ships of 2.998 pounds, at 9 knots, and 2.359 pounds, as against the mean for the four ships of 2.237 pounds, at 12½ knots. The coal consumption of the Schulz boilers in H. I. M. S. *Nymphé* was, so long as the coal lasted, on a full-speed continuous run, as low as 2.171 pounds per I. H. P.

From these figures it will be seen that the reproach of being uneconomical can not be indiscriminately applied to all water-tube boilers.

VIII.—EFFICIENCY OF THE VARIOUS SYSTEMS.

1. *Calculated on the basis of floor space.*—The efficiency of the boilers referred to in this article, calculated on the amount of floor space taken up by them, depends upon the extent of forcing permissible, the grate area which can be fitted with a given boiler-room floor space being almost similar in all the systems. In the ships already fitted with water-tube boilers in the German navy the amount of grate surface per square foot of boiler-room floor space is as follows:

Type of boiler.	Square feet of grate area.
Schulz.....	0.177 to 0.267
Dürr.....	.18 to .278
Cylindrical.....	.218 to .264
Thornycroft.....	.18 to .247
Locomotive.....	.118 to .13

If the space available is restricted, a somewhat larger amount of grate surface can be placed within a given floor space by using Dürr boilers than would be possible if small-tube water-tube boilers with adequate sized water chambers were selected.

As with cylindrical boilers, the pressure used in the ashpit is less than half an inch (0.47 inch), which admits of burning not more than about 24.58 pounds of coal per square foot of grate surface per hour, while with the Dürr and Schulz boilers about 37 pounds can be quite conveniently burned, the efficiency of the cylindrical boilers as compared with the water-tube boilers in question, taking the amount of floor space available in the boiler room, stands about as 2 : 3.

2. *Calculated on the weight.*—As regards the weights of boiler installations, these depend considerably upon the amount of forcing the boilers will be subjected to; the smaller the installation is for a given power the less economical will it be for a greater power, because it will then have to be heavily forced, but the installation per I. H. P. will be lighter. A certain limit will be imposed on the makers by the fixing of the maximum coal consumption for the continuous maximum speed runs; the proportions of the boilers for the maximum power of the engines will, however, vary considerably, as the coal consumption is not ascertainable for runs with the maximum power of the engines when the boilers are being forced, only the horsepower per square foot of grate and of heating surfaces being available for the purposes of comparison. From the tabulated details given in Appendix II of the results of trials already carried out with the maximum power of the engines, the following appear to be the powers obtainable:

Type of boiler.	I. H. P.	
	Per square foot of grate surface.	Per square foot of heating surface.
Cylindrical.....	9 to 13.8	0.323 to 0.418
Locomotive.....	16.2 to 23.7	.313 to .532
Dürr.....	11.8 to 17.4	.288 to .388
Thornycroft.....	16.2 to 19.2	.304 to .369
Schulz.....	15 to 17.1	.274 to .334

Nevertheless the mean values ascertained from the comparative results shown in Appendix II afford a standard for judging the efficiency of the several systems as measured by their weight. According to these mean values the weight of the boiler installations—that is, the weight of the boilers—with uptakes and funnels, including

all the auxiliary engines with their steam and water connections in the boiler room used for working the boilers, stands to the powers obtained as follows:

Type of boiler.	I. H. P.		Pounds per I.H.P.
	Per square foot of grate surface.	Per square foot of heating surface.	
Cylindrical	12.5	0.390	161
Cylindrical and Schulz	13.6	.328	131
Cylindrical and Thornycroft	13.7	.352	130
Dürr	14.6	.347	111
Locomotive	20.8	.427	106.8
Belleville	12.5	.398	103.2
Nielause	13.3	.396	91.5
Schulz	16	.304	85.5
Thornycroft	17.2	.332	81.2

The figures given in the table of Appendix II also show approximately how much more weight can be spared by using the various boiler systems, if the work done by the boiler is further increased. For this, however, the statements of the coal consumption shown in the tables of Appendix I for continuous maximum speed runs with all the boilers at work must be taken into consideration, because these values have a close connection with the powers obtained from the boilers; whereas when running at ordinary speed as many boilers can be used as are required to prevent the work done by any single boiler being too great.

It is evident that the values of the weight of each individual boiler installation per I. H. P. is affected by the efficiency of the engines, and also by all the little contingencies met with in the trial runs, and by the greater or lesser skill of the stokers; it would therefore be expedient to obtain a larger amount of data from which to draw comparisons in order to obtain more reliable mean values. According to the data in regard to weights here collected, the choice of a mixed boiler installation on board battleships leads to a saving in weight of $\frac{158.7-128.6}{158.7}$ = about 20 per cent over an installation of cylindrical boilers only. For this class of ship this represents some 190 tons, which can be utilized either in coal, thereby increasing the radius of action, or in some other way. By the installation of Dürr boilers a further saving of some 19 pounds per I. H. P. would be affected, which, with 15,000 I. H. P., would mean a further gain of some 120 tons; if Schulz boilers were to be chosen, the saving in weight over mixed boilers would be some 44 pounds per I. H. P., equal to a further reduction of about 270 tons.

IX.—COST OF THE VARIOUS SYSTEMS.

It is difficult to ascertain the cost of the various systems of boilers, because those in the imperial yards have been constructed at various times, and, consequently, under varying conditions of trade and of the labor market, etc., while on the other hand the tenders from private yards seldom give any details that can be used for purposes of comparison. Again, the cost per I. H. P. is greatly influenced by the amount of forcing the boilers can be subjected to, and also by the efficiency of the engine installation.

In order to be able to form a rough estimate a few figures are given as to the cost of some installations. The Schulz boiler installation for H. I. M. S. *Württemberg* cost £26,613 15s. These boilers are very lightly worked. If they were to be forced approximately to the same extent as in the case of H. I. M. S. *Nymphé* on the occasion of her six hours' acceptance trial under forced draft, i. e., to a development of 17.58 I. H. P. persquare foot of grate area, and 0.315 I. H. P. per square foot of heat-

ing surface, the steam generated would be sufficient to develop 7,100 I. H. P., making the cost of the boiler installation about £3 15s. per I. H. P.; this figure is approximately the same as the estimate of the Schiff- und Maschinenbau-Aktien-Gesellschaft Germania for a Schulz boiler installation.

Principal data of boilers for the German navy.

APPENDIX I.

RESULTS WITH TRIPLE-EXPANSION ENGINES.

Ship.	Contractors' acceptance trials.				Under ordinary working conditions.			
	Continuous maximum speed run.		Ordinary speed.		Continuous maximum speed run.		Ordinary speed.	
	Coal per square foot of grate.	Coal per I. H. P.	Coal per square foot of grate.	Coal per I. H. P.	Coal per square foot of grate.	Coal per I. H. P.	Coal per square foot of grate.	Coal per I. H. P.
<i>I. Cylindrical boilers.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Brandenburg.....	20.2	1.76	12	1.64	19.3	1.82	16.6	2.33
Kurfürst Friedrich Wilhelm.....	18.5	1.74	12.9	1.83	17.2	1.89	15.2	2.42
Weissenburg.....	18.6	1.66	12.3	1.74	19	1.85	16.6	2.29
Wörth.....	19.2	1.73	9.7	1.58	17	2.11	14.4	2.1
Kaiserin Augusta.....	14.7	1.88	12	1.99	20.6	1.94	11.8	1.84
Gefion.....	16	1.73	10.7	2.22	23.1	2.08	.....	.....
Cormoran.....	20.5	1.96	16.1	2.62	17	2.7	.....	.....
Condor.....	18.3	2.07	10.2	1.69	16.9	2.85	.....	.....
Geier.....	15.5	1.79	13.4	2.2	14.6	2.7	.....	.....
Pelican.....	14.2	1.81	4.65	1.87	.....	.....	.....	.....
Buzzard.....	20.7	2.29	12.8	2.72	.....	.....	16.5	3.22
Hohenzollern.....	12.5	1.95	.....	.....	16.8	2.04	.....	.....
Mean.....	17.4	1.86	11.5	2.01	18.2	2.2	.....	.....
<i>II. Locomotive boilers.</i>								
Siegfried.....	18.1	1.97	6.7	1.87	29.7	3.17	.....	.....
Beowulf.....	23.9	1.77	15.9	1.87	.....	.....	.....	.....
Frithjof.....	29.2	1.99	17.6	2.18	.....	.....	.....	.....
Hildebrand.....	35.3	2.15	19	2.57	.....	.....	.....	.....
Heimdall.....	30.2	1.92	18.1	2.27	.....	.....	.....	.....
Hagen.....	31.4	1.87	.....	.....	.....	.....	.....	.....
Odin.....	24.9	1.94	9.05	2.4	.....	.....	.....	.....
Hela.....	28.8	1.89	17.3	2.19	.....	.....	.....	.....
Wacht.....	28.6	1.82	.....	.....	.....	.....	.....	.....
Jagd.....	40	2.29	.....	.....	26.5	1.81	.....	.....
Comet.....	28.1	1.92	16.7	2.26	.....	.....	.....	.....
Meteor.....	19.9	2.22	14	2.57	.....	.....	.....	.....
Mean.....	28.2	1.98	14.9	2.23	.....	.....	.....	.....
<i>III. Dürr boilers.</i>								
Baden.....	19.6	2	15	2.32	22.4	2.62	20.4	2.94
Bayern.....	17.2	1.56	14	1.97	26.6	2.28	20.6	2.39
Sachsen.....	23.06	2.06	.....	.....	23.3	1.98	.....	.....
Victoria Luise.....	19.2	1.99	13.9	1.86	.....	.....	.....	.....
Vineta.....	.....	.....	13.2	2.08	.....	.....	.....	.....
Mean.....	19.7	1.91	14	2.06	24.1	2.29	.....	.....

Principal data of boilers for the German navy—Continued.

APPENDIX I—Continued.

RESULTS WITH TRIPLE-EXPANSION ENGINES—Continued.

Ship.	Contractors' acceptance trials.				Under ordinary working conditions.			
	Continuous maximum speed run.		Ordinary speed.		Continuous maximum speed run.		Ordinary speed.	
	Coal per square foot of grate.	Coal per I. H. P.	Coal per square foot of grate.	Coal per I. H. P.	Coal per square foot of grate.	Coal per I. H. P.	Coal per square foot of grate.	Coal per I. H. P.
IV. <i>Thornycroft boilers.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Ægir	22.4	1.69	10.4	2.15	24.5	1.94	23.9	3.32
Three days' run ..					28.6	2.08	25	2.72
Iltis	24.9	1.6	21.8	1.99				
Jaguar.....	24.9	1.69	19.7	1.84				
Tiger	39.1	2.79	21.6	3.31				
Luchs	28.6	2.12	16.4	2.9				
Niobe.....	17.4	1.89	19	2.16				
Mean	23.6	1.79	17.5	2.21				
V. <i>Schulz boilers.</i>								
Württemberg.....	26.9	2.29	21.6	2.23	26.6	2.51		
Nymphe.....			11.8	1.67				
Three days' run ..	26.6	2.1						
Mean	26.7	2.18	16.7	1.96				
VI. <i>Niclausse boilers.</i>								
Gazelle	15.4	1.81	12.4	1.93				
Freya.....								
Mean								
VII. <i>Belleville boilers.</i>								
Hertha	17.5	2.03	7.65	2.17	19.2	2.18	13.5	3.94
Hansa	16.6	1.99	8.6	1.85				
Mean	17.1	2.01	8.12	2.01				
VIII. <i>Mixed system— Cylindrical-Thornycroft.</i>								
Kaiser Friedrich III...	14.1-21.9	1.84			18.1-35.4	2.54		
IX. <i>Mixed system— Cylindrical-Schulz.</i>								
Kaiser Wilhelm II.....	14-20.7	1.82						
Fürst Bismarck								

Principal data of boilers for the German navy—Continued.

APPENDIX II.

PARTICULARS OF THE SEVERAL BOILER INSTALLATIONS.

[The boiler-room weights include boilers, pipes, auxiliary engines, funnels, etc.]

Ship.	Maximum continuous I.H.P. developed.	Total weight of boiler.	Grate surface.	Heating surface.	I.H.P. per square foot of grate surface.	I.H.P. per square foot of heating surface.	Total weight per I.H.P.
I. Cylindrical boilers.		Tons.	Square feet.	Square feet.			Pounds.
Brandenburg.....	9,863	728	753	24,640	13.1	0.400	165.6
Kurfürst Friedrich Wilhelm.....	9,850	732	753	24,640	13	.398	166.7
Weissenburg.....	9,964	717	753	24,640	13.2	.402	161.5
Wörth.....	10,330	693	753	24,640	13.7	.418	150
Kaiserin Augusta.....	14,310	905	1,033	35,700	13.8	.400	141.5
Gefion.....	9,116	598	715	22,700	12.7	.402	147
Cormoran.....	2,816	203	224	7,534	12.5	.374	162.1
Condor.....	2,840	193	226	7,050	12.5	.402	152
Geier.....	2,920	209	226	7,050	12.9	.415	161
Pelican.....	3,028	219	258	8,400	1.7	.361	161.8
Buzzard.....	2,770	213	226	7,150	12.2	.384	173
Hohenzollern.....	9,325	778	1,033	28,800	9	.323	187.5
Mean.....					12.5	.390	161
II. Locomotive boilers.							
Siegfried.....	4,725	200	232	10,763	20.4	.438	95.2
Beowulf.....	4,810	222	219	11,850	22	.406	103.8
Frithjof.....	4,900	221	219	11,850	22.3	.412	101.2
Hildebrand.....	5,260	220	222	9,850	23.7	.532	93.8
Heimdall.....	4,336	231	213	10,610	20.2	.408	120
Hagen.....	4,552	240	213	10,610	20.9	.42	120.8
Odin.....	3,481	243	215	10,615	16.2	.328	156
Hela.....	5,925	237	281	12,500	21.1	.472	89.2
Wacht.....							
Jagd.....	3,430	169	162	11,000	21	.313	110.9
Comet.....							
Meteor.....	4,676	157	232	9,200	20.1	.508	75.2
Mean.....					20.8	.427	106.8
III. Dürr boilers.							
Baden.....	6,118	347	517	16,750	11.8	.366	127
Bayern.....	6,280	348	454	21,800	13.8	.288	124.5
Sachsen.....	6,370	323	437	18,250	14.5	.348	113.6
Victoria Luise.....	10,420	408	674	29,850	15.4	.346	88.2
Vineta.....	10,500	472	600	27,000	17.4	.388	101
Mean.....					14.6	.347	111
IV. Thornycroft boilers.							
Ægir.....	4,909	192	274	16,150	17.9	.304	87.6
Three days' run.....							
Iltis.....	1,358	466	818	4,098	16.6	.331	77
Jaguar.....	1,358	471	818	4,098	16.6	.331	77.7
Tiger.....	1,351	541	818	5,098	16.5	.331	90
Luchs.....	1,325	542	818	4,098	16.2	.324	91.6
Niobe.....	8,000	226	416	2,176	19.2	.369	63.2
Mean.....					17.2	.332	81.2

Principal data of boilers for the German navy—Continued.

APPENDIX II.

PARTICULARS OF THE SEVERAL BOILER INSTALLATIONS—Continued.

Ship.	Maximum continuous I. H. P. developed.	Total weight of boiler.	Grate surface.	Heating surface.	I. H. P. per square foot of grate surface.	I. H. P. per square foot of heating surface.	Total weight per I. H. P.
<i>V. Schulz boilers.</i>		<i>Tons.</i>	<i>Square feet.</i>	<i>Square feet.</i>			<i>Pounds.</i>
Württemberg.....	6,177	292	412	22,500	15	.274	106
Nymphen.....	8,375	243	488	25,000	17.1	.334	65.3
Three days' run							
Mean					16	.304	85.5
<i>VI. Niclausse boilers.</i>							
Gazelle	6,275	252	462	15,650	13.6	.402	90
Freya.....	10,100	417	775	25,850	13	.390	92.7
Mean					13.3	.396	91.5
<i>VII. Belleville boilers.</i>							
Hertha	10,050	449	795	24,000	12.6	.400	100.5
Hansa	9,928	472	795	24,000	12.4	.395	106.8
Mean					12.5	.398	103.2
<i>VIII. Mixed system—Cylindrical-Thornycroft.</i>							
Kaiser Friedrich III....	12,860	{ 593 154	{ 655 280	{ 23,280 13,250	{ 13.7	.352	130
<i>IX. Mixed system—Cylindrical-Schulz.</i>							
Kaiser Wilhelm II							
Fürst Bismarck.....	13,420	785	{ 655 327	{ 23,400 17,450	{ 13.6	.328	131

The cylindrical boilers in the mixed installation on board H. I. M. S. *Kaiser Friedrich III* on the six hours' official trial, when the engines developed 13,000 I. H. P., are credited with a development of about 13 I. H. P. per square foot of grate surface. If, however, an air pressure of only 0.47 inch is used and the consequent development attained is not more than 11.61 I. H. P. per square foot of grate area and 0.325 I. H. P. per square foot of heating surface, then the power developed by the cylindrical boilers would be only 7,600 I. H. P. As this part of the installation cost £32,950, the cost per I. H. P. on this assumption would be about £4 6s. 8d.

An installation of Dürr boilers, if the arithmetical mean is assumed as being correct, would, according to the last tenders submitted by private firms, cost about £3 10s. per I. H. P. By taking other data for working out the calculations, the difference in price, however, comes out extremely small, the Dürr boilers in certain cases even coming out somewhat dearer than cylindrical and Schulz boilers. According to a report from the imperial yard at Kiel, the following prices have been paid for the boilers, with casing plates and lagging, of the ships built at the yard during the last few years, viz: For cylindrical boilers, £1 15s. 4d.; for Dürr boilers, £1 11s. 6d. to £2 0s. 11d.; for Schulz boilers, £1 15s. 7d. to £1 16s. 10d., calculated on the I. H. P. contracted for.

X.—CONCLUDING REMARKS.

From the foregoing it will be seen that the decision of the German navy to construct Schulz and Dürr boilers, while carrying out experiments with other systems, has been attended with satisfactory results. We may well be contented with the success hitherto attained, and the time may, perhaps, not be far distant when the other naval powers will follow in our footsteps. We began to build water-tube boilers somewhat later than other countries, but it is now recognized abroad that we have consistently progressed, and have now come to the front of other nations, who begin to see that their selection from the various systems has been so unlucky that they have now to search for a better type of water-tube boiler.

It is not improbable that further experience may lead to the adoption altogether of water-tube boilers, and that one type may prove better than the other. For the present, however, the principle has been adopted to fit gunboats and small cruisers, where saving of weight is of special consequence, with Schulz boilers, large cruisers with Dürr boilers, and battleships, which can stand heavy boiler installations somewhat better, with cylindrical and Schulz boilers.

COMMITTEE ON WATER-TUBE BOILERS.

REPORT ON TRIALS OF H. M. S. HYACINTH AND H. M. S. MINERVA.

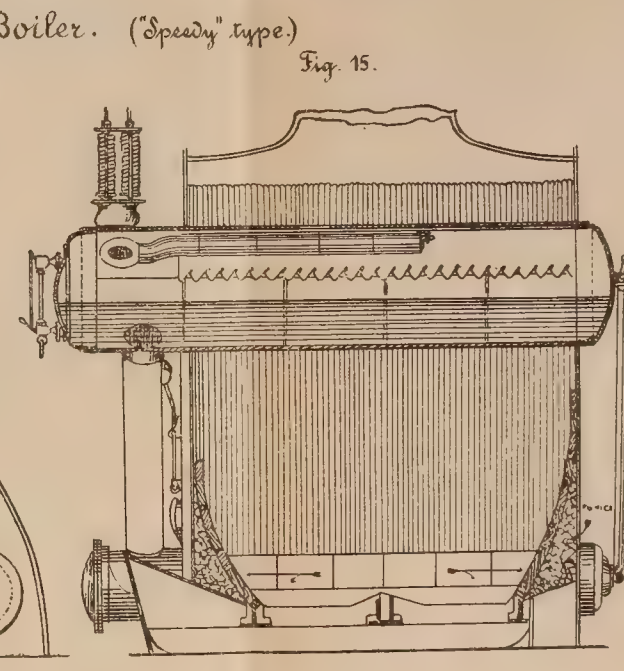
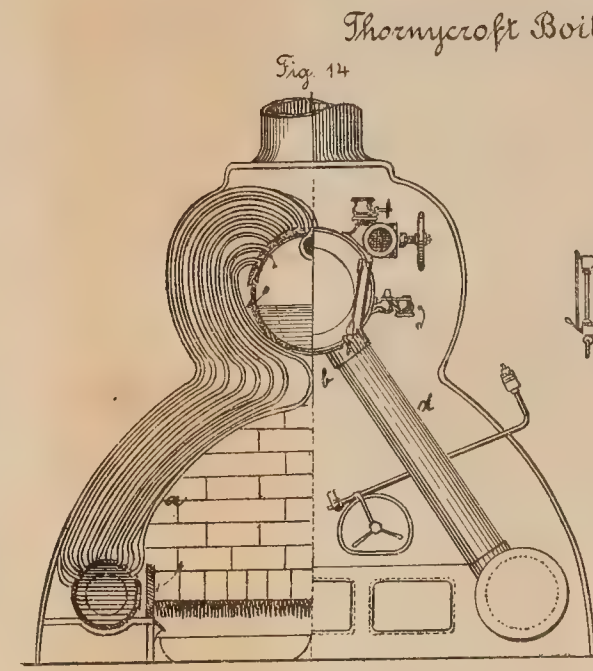
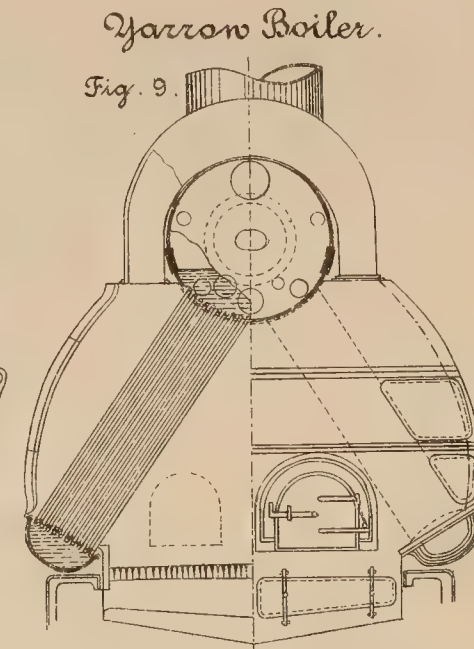
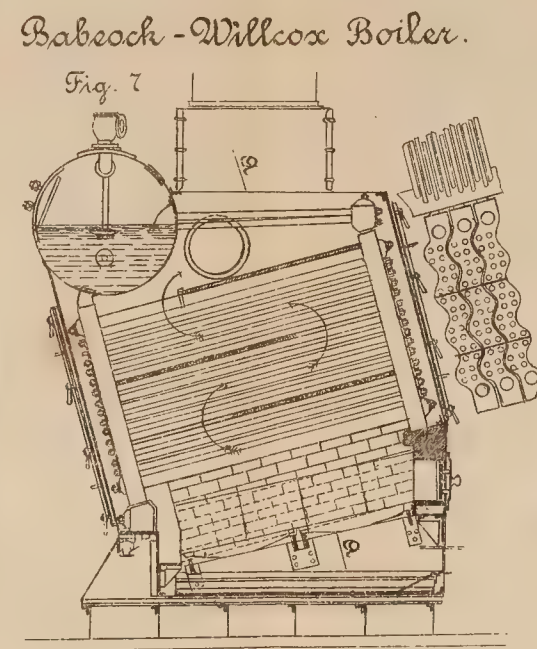
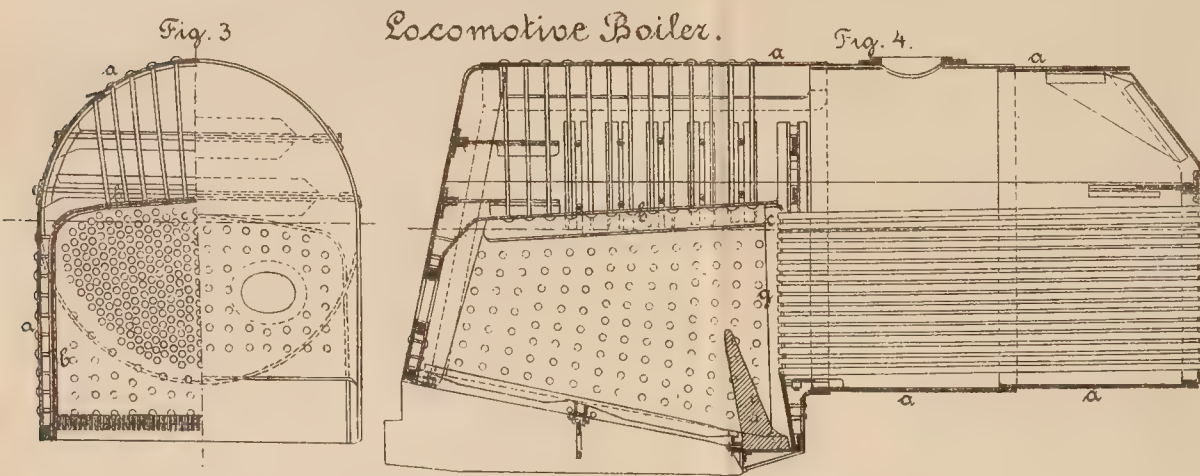
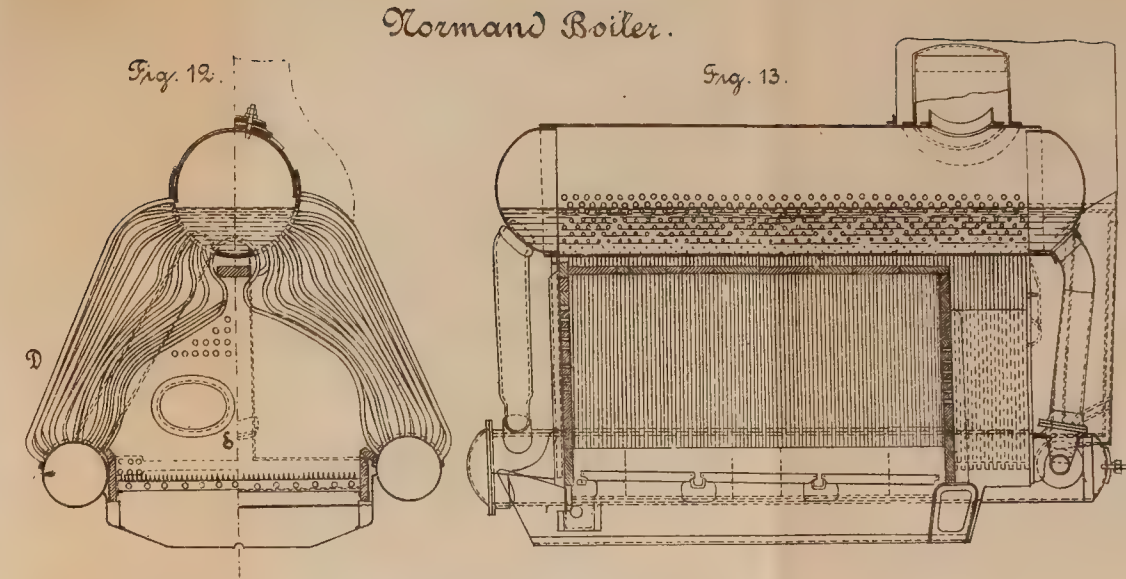
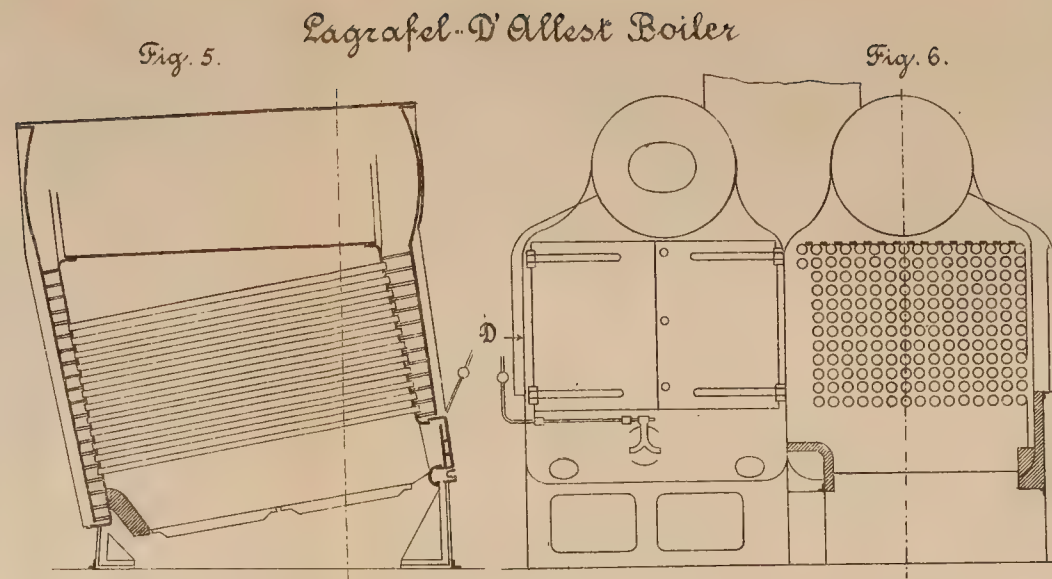
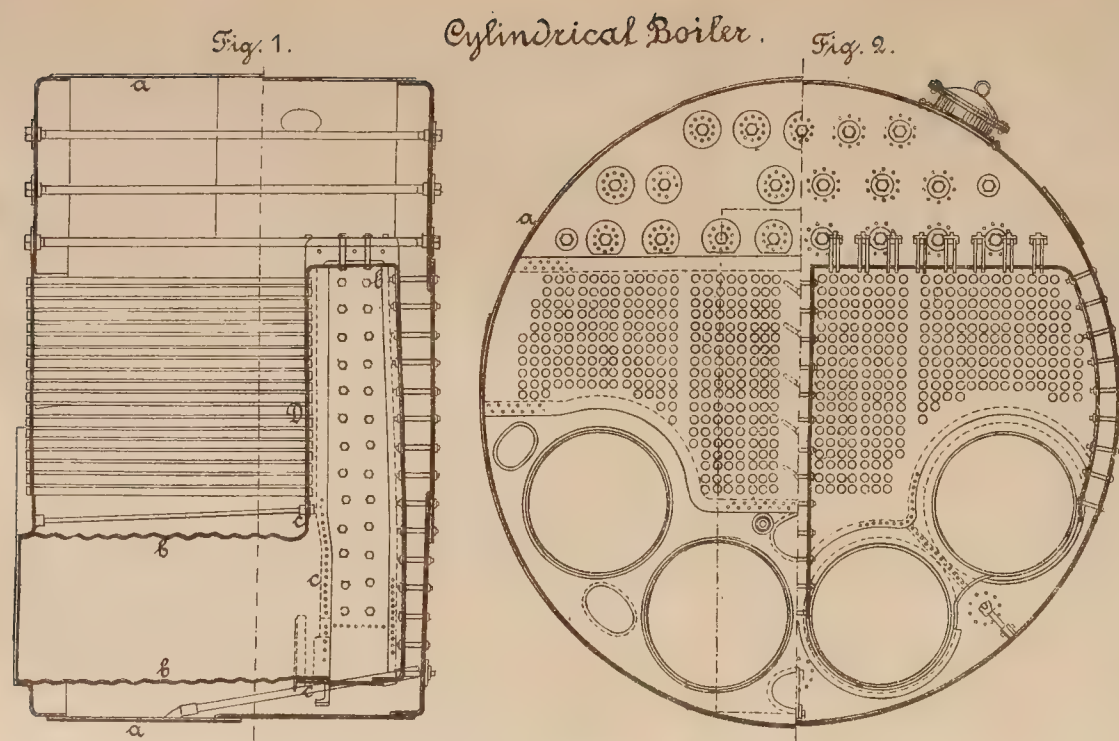
This report covers the complete results of the trials of Her Majesty's ships *Minerva* and *Hyacinth*, carried out under the direction of the committee.

The trials of the *Minerva* and *Hyacinth* were carried out so as to be, as far as possible, strictly comparable. They each included a preliminary trial and trials at about 2,000, 5,000, and 8,000 horsepower. In the case of the *Minerva* there was an additional trial at about 5,000 horsepower to examine the effect of using retarders in the boiler tubes, and in the case of the *Hyacinth* there was an additional trial at her full power, about 10,000 horsepower. In each case, also, there was a long run from the English Channel to the Mediterranean at about 7,000 horsepower, followed by a run home from Gibraltar to Portsmouth at the highest speed possible. All these trials, except the two last, took place in the English Channel.

The principal figures in connection with all these trials are set forth in the tables and diagrams appended to this report, of which the following is a summary: Table I gives the principal dimensions and particulars of the two vessels and their machinery, so far as they affect the committee's trials; Table XXV is a summary table giving the results deduced from all the observed figures as to the performance of the boilers, and Table XXVI gives similar figures for the performance of the engines.

It will be seen from Table I that the *Minerva* and *Hyacinth* are vessels of very nearly the same dimensions. The *Minerva* was first commissioned in February, 1897. She has triple-expansion, 3-cylinder, 3-crank, twin-screw engines, designed to indicate 8,000 horsepower with about 0.5 inch of air pressure and closed stokeholds, and on her contractors' trials she was run up to a maximum of 9,900 horsepower. Her boilers are of the ordinary cylindrical type, and their safety valves are set at a pressure of 155 pounds per square inch.

The *Hyacinth* has 4-cylinder, 4-crank, triple-expansion engines (two low-pressure cylinders), and obtained on the contractors' trial a maximum horsepower of 10,447, with 0.25 inch of air-pressure in the stokeholds. The engines are fitted with a "closed-exhaust" system. In this system the exhausts from the auxiliary engines are connected so as to deliver into the low-pressure receivers of the main engines, so that practically all these engines work compounded, or, in the case of the electric-light engines, tripled. The auxiliary engines are also arranged so as to exhaust to the evaporators, auxiliary condensers, or the atmosphere. Her boilers are of the

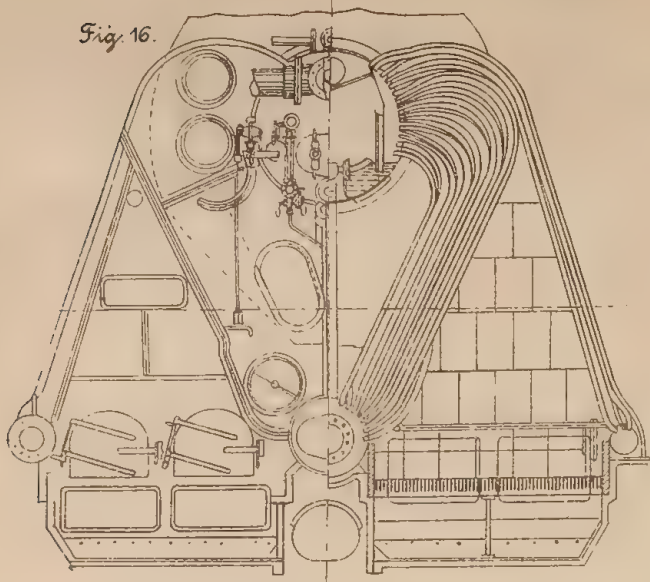


TYPES OF WATER-TUBE BOILERS.



Thornycroft Boiler. ("Daring" type)

Fig. 16.



Schulz Boiler.

Fig. 17.

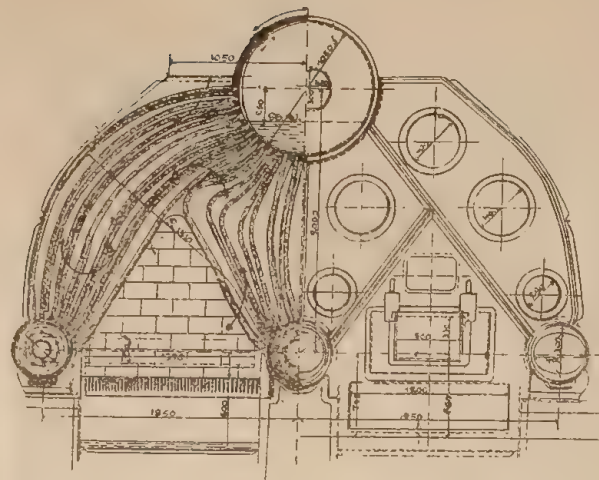
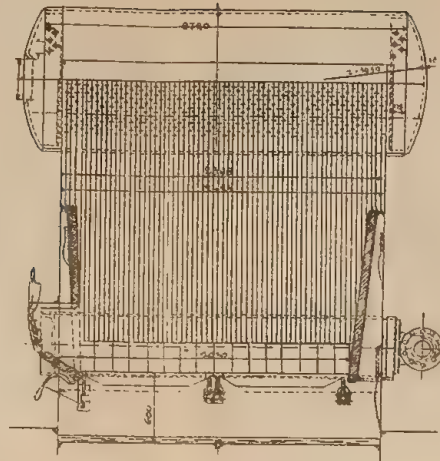


Fig. 18.



Nicklausse Large Tube Boiler

Fig. 19.

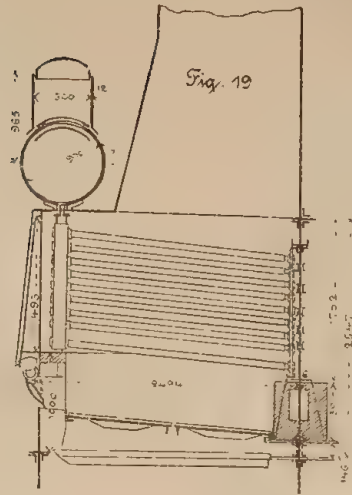
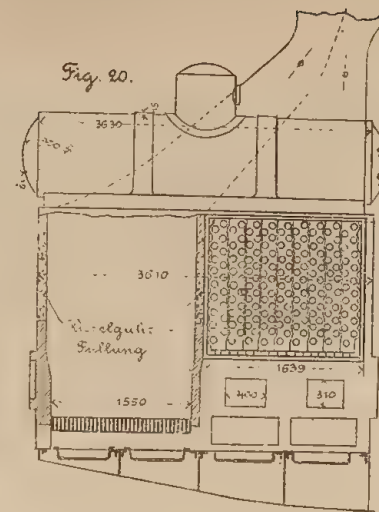


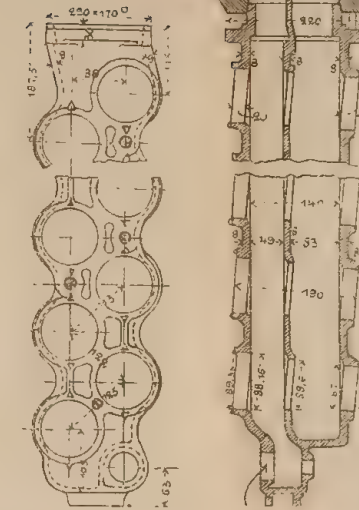
Fig. 20.



Header of Nicklausse Boiler.

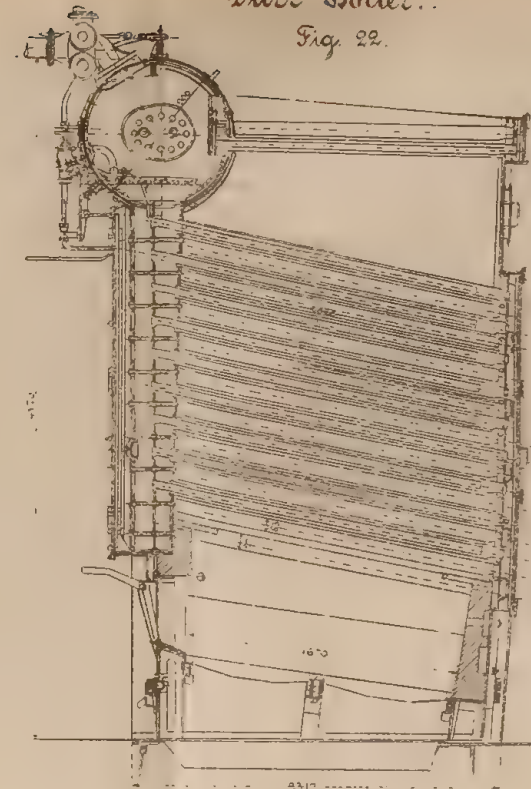
Fig. 21.

1 Element of the Water Chamber.



Dürr Boiler.

Fig. 22.



Belleville Boiler.

Fig. 23.

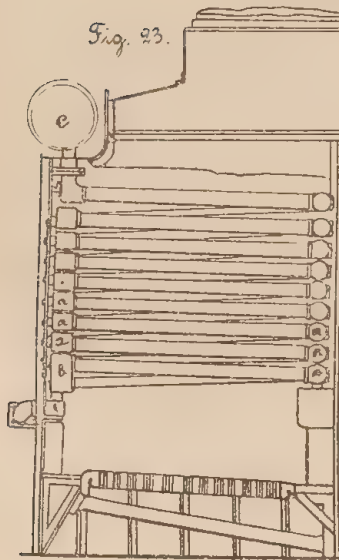
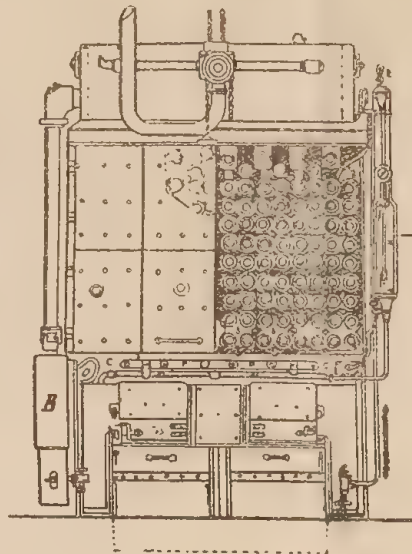


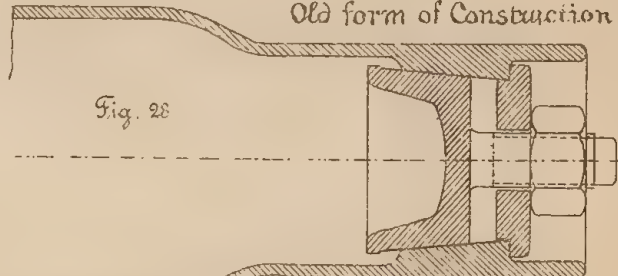
Fig. 24.



Stoppers at Back-end of Tubes of Dürr Boiler.

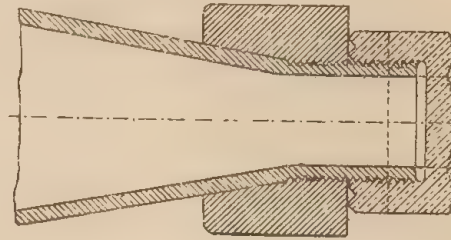
Old form of Construction.

Fig. 28.



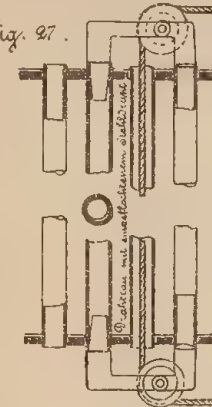
New form of Construction.

Fig. 29.



Guiding Rollers for Steel Wire and Brushes.

Fig. 27.



Steel Wire Brushes.

Fig. 25.

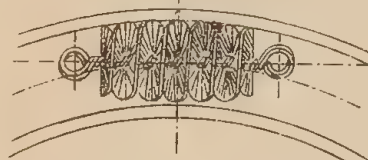
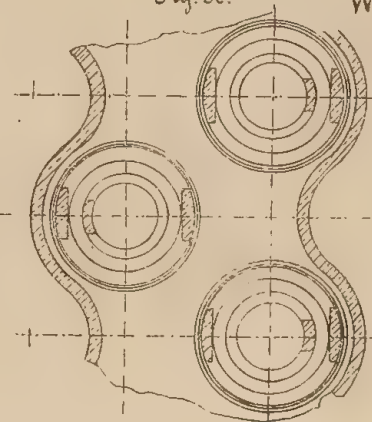


Fig. 30.



(Fig. 30-33.)
Water Chamber or "Header" of Nicklausse Boiler.

Fig. 31.

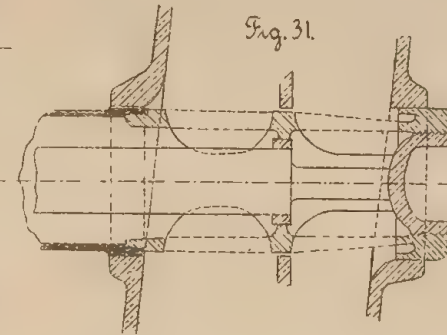
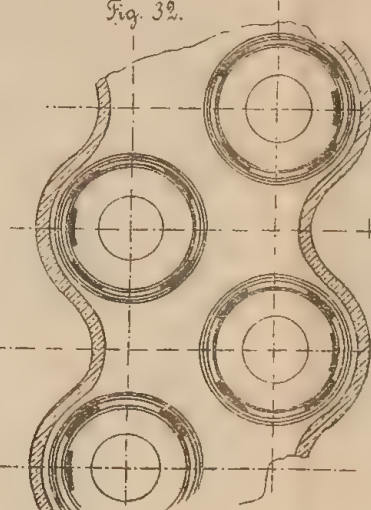
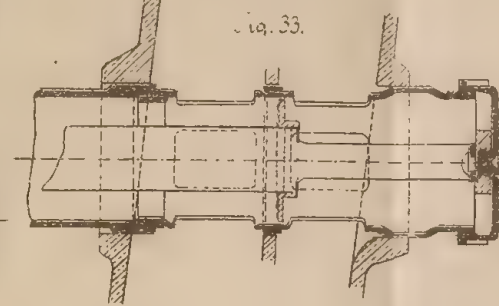


Fig. 32.



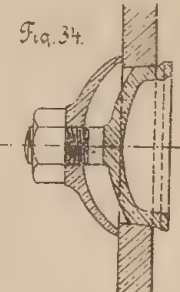
New Form of Lantern.

Fig. 33.



Covering Doors of Front of Dürr Boiler.

Fig. 34.





Belleville type, with economizers, and their safety valves are set at a pressure of 320 pounds per square inch. She was first commissioned in September, 1900.

The *Minerva* is therefore an example of the engines and boilers designed for use in Her Majesty's service five years ago, and has had none of the later improvements added. Her boilers are of the cylindrical type, and they were not originally fitted with retarders in the tubes. The trials at 2,000, 5,000, and 8,000 horsepower were run without retarders. The engines are of comparatively slow revolution type, with moderately long stroke, and the auxiliary engines are not fitted with the system of closed exhaust which has resulted in considerable economy in later vessels. The *Minerva* also, having been in commission for four years, had had a corresponding amount of wear and tear. Her machinery was thoroughly overhauled and both high-pressure cylinders rebored before the trials, but it could not have been a matter for surprise if she had shown some signs of falling off in performance; and still less would it have been surprising had she shown some comparative want of economy all around, due to the fact that she contained none of the economical improvements of the last five years.

The *Hyacinth* is a new vessel, which had not at the time of the trials ever been on actual service. She is fitted with the latest modifications of design due to Admiralty experience, including Belleville boilers with high steam pressure, quick-turning and short-stroke engines, and closed-exhaust system. From the end of the year 1900 until May, 1901, when the committee's trials began, she had been in dock yard hands with the object of insuring her perfect condition.

It is desirable that these points should be kept in view in considering the comparative performances of the two ships.

On account of the great importance attaching to these trials, it was decided by the committee that they should be as complete as possible. For this purpose the coal used was analyzed in each case, samples of the furnace gases were collected during the trials and also analyzed, and the whole of the water delivered from the main engines and from the auxiliary plant, as well as the make-up water added during the trials and pumped into the boilers, was measured. The coal also was weighed throughout. Other special measurements were made, as further described below.

The records were in all cases taken by a staff from Portsmouth Dockyard, under the direction of Mr. A. Burner, R. N., an assistant to the chief engineer of that yard. The same men were in nearly every case employed throughout the various trials in taking similar records. The dockyard staff also worked out and checked the horsepower from the indicator diagrams and the totals and averages of all records.

Coal.—The coal used on the trials of the *Hyacinth* and *Minerva* (not including the runs to and from Gibraltar) was hand-picked Welsh coal, and care was taken that the coal used by the two ships should be, as far as possible, of identical quality. It will be seen from the analyses in Table XXV that this result has been obtained very closely. The stokehold plates were swept clean at the commencement and at the end of each trial, and the fires examined at the same times. All coal used was brought from the bunker doors to the fires in "skids," every skid of coal being carefully weighed by slinging from a tested spring balance, and brought to a particular amount. The hourly records which are given in the tables show the amount of coal taken from the bunkers and weighed onto the floors in each hour exactly as tallied, but it is to be noted that these figures must not be taken as representing the actual amount burned in each intermediate hour, as the floors were only cleared at the beginning and end of the trial. The work of weighing and tallying the skids was carried out by chief petty officers from the Portsmouth reserve taken out on the trials under the direction of an engineer officer for this particular purpose.

Coal analysis.—Pieces from the coal about to be fired were taken off each stokehold floor at frequent intervals during each trial and put on one side. The whole of these were mixed together after the trial, and about 2 hundredweight of the coal so

mixed was sent in each case to Mr. Wilson for analysis. This whole amount was very carefully ground and mixed to obtain the sample from which the analysis was made. In each case an experimental determination of the thermal value of the coal was made in a bomb calorimeter, using compressed oxygen. The ash and moisture were also determined experimentally in each case, but the thermal values of the different samples were so exceedingly similar that it was not thought necessary to make complete analyses of all. The thermal values calculated from the analyses which are given agree very closely with the values determined by experiment.

Temperatures.—The temperatures of the flue gases were taken by Callendar electric thermometers, and read on a galvanometer made by the Cambridge Scientific Instrument Company for the special purpose of these trials. The whole temperature-taking apparatus worked satisfactorily throughout. The records were taken regularly from two to four times per hour, as shown in the tables.

In the *Minerva* the temperatures of the flue gases were taken in the uptakes of the two after boilers and very close to the boilers.

In the *Hyacinth* the temperatures of the flue gases were taken at the base of the foremost funnel in the uptake from No. 2 boiler (see Table XXXIII), about 10 feet above the top of the economizer tubes, and also in the midship funnel just above the level of the upper deck. The former readings were the higher, and have been taken into account in estimating the average temperature of the flue gases.

Flue gases.—Samples of the flue gases were taken on all the trials, these being collected in every case over mercury, the suction being effected by mercury displacement. The samples were collected from the funnel at the same place as the upper point where the temperatures were measured. For this purpose a piece of 1½-inch tubing with numerous one-fourth inch holes in it was placed right across the funnel. A one-eighth inch pipe with one-sixteenth inch holes in it was carried across the funnel inside the larger one. This small pipe, carried to the outer air through a screwed gland, was connected by india-rubber tubing (tested for air leakage every time a sample was collected) to the mercury suction apparatus. The samples were collected at regular intervals, once every hour or half hour, according to the length of trial. In some cases each whole sample was collected in about two minutes, in others its collection was distributed continuously over about twenty minutes, but the final results show no difference in analysis corresponding to the difference in times of collection. All the samples collected were analyzed, and the mean analyses are given in Table XXV. Unfortunately, the tubes containing the gases taken on the *Hyacinth's* trial of June 10 were broken, so that no analysis for this trial can be given.

Steam dryness.—The moisture in the steam was measured by means of a Carpenter calorimeter. In the *Minerva* this was connected to the steam pipe between the regulating valve and the high-pressure valve chest of the port main engines, no separators being fitted in the steam pipes.

In the *Hyacinth* the calorimeter was connected to the steam pipe in No. 5 stokehold and on the boiler side of the separator.

Steam temperatures.—The temperatures of the steam were taken by platinum thermometers similar to those used for the flue-gas temperatures, and read on a galvanometer in the same manner.

In the *Minerva* the steam temperatures were taken (1) in the run of steam piping in the after boiler room, and (2) between the regulating valve and the high-pressure valve chest of the port main engines.

In the *Hyacinth* the steam temperatures were taken (1) in the run of the steam piping on the port side of the middle boiler room, and (2) between the regulating valve and the high-pressure valve chest of the port main engines.

Pressures.—The steam pressures in the boilers and in the engine room, as well as the pressures in the various receivers, jackets, etc., were noted from the ship's gauges,

and the readings of these gauges are given in the tables. The observed temperatures of the steam and the initial pressures measured from the indicator cards serve as checks on the steam pressures in the boilers and at the engines, the thermometer readings being certainly much more trustworthy than those of the pressure gauges.

Power.—Indicator cards were taken at half-hourly intervals on all the trials except on the trial of the *Minerva* on March 15, when they were taken every twenty minutes. The indicators used were obtained from Her Majesty's dockyard at Portsmouth, the springs having been carefully tested previous to the trials and between consecutive trials when any length of time elapsed.

Revolutions.—For obtaining the revolutions of the main engines a special set of counters from the dockyard was used, and the results obtained from these were checked by independent observations of the ordinary engine-room counters. The number of revolutions recorded by these counters for the interval between two consecutive readings divided by the number of minutes in the interval was taken as the average number of revolutions per minute for that interval, and used in the calculation of the horsepower for the indicator diagrams taken during the interval.

Water measurements.—For the measurement of the water discharged from the engines a pair of tanks was used for each set of main engines, these tanks being filled and emptied alternately and each time of filling noted. The tanks were graduated, and the filling arranged in each case so that it lasted from eight to fifteen minutes.

In the *Hyacinth* and *Minerva* the water was delivered to these tanks (which were placed on the upper deck) by the hot-well pumps, which took the water from the engine hot-wells, where it was delivered by the main air pumps. From the measuring tanks the water passed by gravity through the feed filters into the engine-room feed tanks, and from these was drawn direct by the boiler feed pumps.

All overflows on the engine-room feed tanks were blanked off and all air pipes connected with the feed tanks, and in the *Minerva* and *Hyacinth* with the filters also, were carried as high as the top of the measuring tanks, so that the measuring tanks, filters, and feed tanks, with their connecting pipes, formed a closed system.^a The measuring tanks received in this way the whole of the water discharged by the main air pumps. In other words, the whole of the water which had passed through the main engines.

In the *Hyacinth*, when the closed exhaust was not in use, and in the *Minerva* a separate pair of measuring tanks was used to receive all the water from the auxiliary condensers, which represented the steam used by the auxiliary engines.

The water drawn from the jackets, when these were used, was measured by a separate tank, which was alternately filled and emptied.^b

The amount of make-up water used was measured in a separate tank and delivered into the closed feed system from time to time, as required, in order to preserve the level reasonably constant in the main feed tanks. This make-up feed water was pumped by a special pump from the reserve tanks in the ship's double bottoms. The evaporators were not used during any of the trials before the run to Gibraltar.

The engine-room feed tanks and the hot-well tanks were in all cases calibrated before the trials, and fitted with water gauges with indices attached to them. The quantity of water in these tanks at the beginning and end of each trial was recorded, and any differences allowed for.

In the *Hyacinth* as long as the closed-exhaust system was in use it was of course

^aIn the case of the first trial of the *Minerva* this arrangement was not exactly followed.

^bOn the 2,000 horsepower trial of the *Minerva*, owing to the leakage of a valve, the jacket water could not be accurately measured. The separate amount given for this trial is therefore estimated and not measured.

impossible to measure the steam used by the auxiliary engines separately. It will be seen, therefore, that for the trials at 2,000, 5,000, and 8,000 horsepower the greater part of the whole duration of each was run with the closed-exhaust system in use, and the measurements give only the water used by the main and auxiliary engines together. To find out how much steam the auxiliaries would use if separately exhausted, so as to form some idea of the saving due to the use of the system, the closed exhaust was put out of use for a portion of each trial and the auxiliary engines discharged into the auxiliary condensers. For this portion of each trial the amount of steam used by the auxiliaries was determined separately, as mentioned above.

The final results obtained from the trials are summarized in Tables XXV and XXVI. In these tables the corresponding pairs of trials of the *Minerva* and *Hyacinth* are placed in adjacent columns. These are followed by the full-power trial of the *Hyacinth*, which has no corresponding trial with the *Minerva*, and this again by the *Minerva's* trial with retarders. It will be seen that the weather during all the trials was good, so that none of them were interfered with or in any way rendered difficult on this account.

Taking, first (Table XXV), the boiler trial results, and comparing the figures for the two cruisers, it will be noted (line 50) that at 2,000 and 5,000 horsepower the *Minerva's* coal consumption per square foot of grate (with the number of boilers actually in use in each case) was somewhat less than that of the *Hyacinth*, but that at higher powers the larger grate area of the *Hyacinth* reversed this ratio, so that at 8,000 horsepower the *Minerva* was burning 30.3 pounds per square foot, as against 19.8 on the *Hyacinth*, the latter ship only burning 27.2 pounds when indicating over 10,000 horsepower. The rate of transmission of heat through the heating surface (line 51) varies similarly, being somewhat smaller in the *Minerva* at the lower powers and very much greater at the higher powers.

The thermal efficiency of the *Hyacinth's* boilers was in each case greater than that of the *Minerva's* at the same power (line 46), and the evaporation per pound of coal from and at 212° varied, of course, in the same way (line 49). The difference is considerable at 2,000 horsepower, small at 5,000 horsepower, and very great at 8,000 horsepower. Fortunately, the completeness of the observations made allows it to be seen at once both to what this difference was and to what it was not due. That it was not caused by the forcing of the *Minerva's* boilers appears from the result of the 2,000-horsepower trial, where they were working very easily. That it was not due to incomplete combustion is also shown very clearly by the figures in line 39, which show this loss to have been practically the same in the two ships at 8,000 horsepower. It appears to have been due entirely to the high funnel temperature and the excess of air in the furnace gases, with the consequent waste of heat up the funnel, in the *Minerva* as compared with the *Hyacinth* (line 40). In the most marked case, viz, at 8,000 horsepower, the loss by incomplete combustion is practically the same in both ships, but in the *Minerva* the air used per pound of coal is nearly 30 per cent greater than in the *Hyacinth*, and the gases are raised 118° F. higher (line 27) in the funnel, the total funnel waste (line 40) being just double.

It is difficult to regulate with certainty the amount of air passed through the fires. This depends partly on boiler design and very largely on stoking, but the use of retarders in the tubes is a well-known and much-used device in merchant steamers for the reduction of funnel temperature. It was therefore thought by the committee very desirable that this simple remedy for a well-known defect should be tried, and this was done by permission of their lordships in the trial of May 29. Retarders were fitted in half the boilers of the *Minerva*, and these boilers were pushed on that trial so that their evaporation might be at least equal to that of four boilers on the 8,000 horsepower trial. The retarders were given two and a half twists in their length, which was the full length of the tube.

The results of the employment of retarders are very remarkable, and may be summarized as follows:

	Without retarders.	With retarders.
Heat transmitted per square foot of heating surface per hour.....B. T. U..	9,560	10,220
Heat utilized per boiler per minute.....B. T. U..	368,000	393,000
Air pressure in stokeholds.....inches of water..	0.81	0.65
Rise of temperature of flue gases.....deg. F..	761	634
Coal used per boiler per hour.....pounds..	2,462	2,363
Water evaporated per boiler per hour.....do..	19,530	20,890
Boiler efficiency.....per cent..	61.4	68.4

It will be seen that, with retarders, the boiler efficiency is practically the same as that of the boilers of the *Hyacinth* under similar conditions.

As it has not been possible to test the *Minerva* over again with retarders at low powers, it can not be said to what extent the boiler efficiency at lower powers would be improved by their use. The very notable results as to coal consumption, however, on the voyages to Gibraltar and back, on which retarders were used in all the boiler tubes except the stay tubes, indicate that their influence was very marked.

In the result it will be seen that, whether from this cause or a combination of causes, the boiler efficiency of the *Minerva* on the two long voyages during which the coal used and the power developed were measured with unusual completeness, appears to have been more than equal to that of the *Hyacinth*.

The flue gases collected on May 29, when analyzed, showed, unfortunately, that for some reason they were not a true sample of the whole gases passing up the funnel. Their analysis is, therefore, not given in the table, as it would be misleading. It is certain, however, that there was still, as in earlier cases and in both ships, a considerable loss due to incomplete combustion.

As to the completeness of the combustion in the furnaces, it will be seen that there is not much to choose between the two vessels. On the 2,000-horsepower trial of the *Minerva* no carbonic oxide was found in the gases, and in the similar trial of the *Hyacinth* very little, but in all the other runs the amount was considerable. The air used per pound of coal was least on the *Hyacinth's* 8,000-horsepower trial, but the proportionate loss due to incomplete combustion was not quite so great as in the *Minerva* at 5,000 horsepower, although the air used in the latter was 23.3 pounds instead of 17 pounds per pound of coal. In connection with these figures it is, however, to be noted that, although the analyses given represent with great accuracy the actual constitution of the samples of gas collected, it is in the nature of things impossible to insure that the gases collected from a particular position in one funnel shall really be a true average sample of the gases passing up the whole area of that funnel, still less that they shall exactly represent the true average constitution of the gases in other funnels. The figures in lines 42 and 45, from which the thermal efficiency of the boilers is calculated, are of course not affected by the analysis of the gases, but the accuracy of those in lines 39, 40, and 44 depends entirely on the extent to which the samples collected correspond to the actual average of the whole gases. The results given in these lines, as well as in lines 24 and 25, are no doubt substantially accurate, but there are several indications that the actual average weight of air per pound of coal on the 8,000-horsepower trial of the *Minerva* must have been somewhat greater than that calculated (line 24) from the composition of the gases.

The Carpenter calorimeter showed no moisture in the steam on any of the *Minerva's* trials. On the two lower power trials of the *Hyacinth* a little wetness was found from time to time (see Tables XVIII and XIX). It ran up occasionally to over 1 per cent, but its average value (line 38) was negligible. At 8,000 horsepower and 10,000 horsepower, however, the priming losses, or losses due to wetness in the steam,

whether strictly priming or not, were considerable, being 4.7 and 6.4 per cent respectively. The regularity of the observations seems to leave no doubt about the reality of this wetness, although the amount of water collected (past the calorimeter connection) in the steam separators was negligibly small. Apparently the whole of the wetness in these cases found its way at least as far as the regulating valves, if not actually into the cylinders.

The loss of steam through leaks in boilers, pipe joints, engine stuffing boxes, etc., is indicated by the figures given in Table XXVI, line 42. It is, of course, impossible to apportion the losses to their various causes, but the results of the Gibraltar runs lead us to look upon leaks at the boilers as being responsible for any abnormal increase in these losses. On the three progressive trials of the *Minerva* the total losses were represented by 2.1, 3, and 3.7 tons of water per 1,000 horsepower per twenty-four hours, respectively. In the *Hyacinth* they were 5.5, 2.9, and 5.5 tons, respectively, and 4.8 tons at 10,000 horsepower. The irregularities here, no doubt, depend mainly on the actual tightness of the boiler joints during the runs. At 5,000 horsepower the *Hyacinth's* losses came out very well, and slightly less than those of the *Minerva* at the same power; at the other powers, both lower and higher, they were very much greater, and it was found later on, during the Gibraltar runs, that on trials of greater duration they became most serious.

No mishap occurred during any of the Channel trials except on the 8,000-horsepower run of the *Hyacinth*, during which a leaky joint put one boiler out of use after about an hour and a half, this boiler not being again available during the run. On all the *Hyacinth's* trials, however, the great irregularity in water level as shown by the gauge glasses, which appears characteristic of the Belleville boiler, was very noticeable. The two gauges on the same boiler frequently showed an apparent difference of many inches, sometimes the one and sometimes the other gauge showing the higher level. The accident which happened to one of the boilers on the run home from Gibraltar, and which is dealt with later on in this report, appears to indicate somewhat clearly the cause to which these irregularities are due.

We may now pass to Table XXVI, which gives the general results of the trials so far as the main engines and auxiliary machinery are concerned, and some figures affecting the combined performance of the engines and boilers.

It will be noted, in the first place, that there was not the least difficulty in either ship in maintaining the power required on the full-power trials. In the *Hyacinth* the fans were running for the higher powers, but no air pressure was recorded in the stokeholds. The *Minerva* used closed stokeholds at 8,000 horsepower and on the retarder trial. The *Hyacinth* ran for eight hours with an average power of 10,180 and the *Minerva* for nine hours with an average power of 8,132. On the Gibraltar runs these results were fully confirmed.

The *Minerva* used the steam jackets on all her channel trials. The *Hyacinth* used low-pressure jackets at 2,000 and 5,000 horsepower, but not at 8,000 nor 10,000 horsepower.

The revolutions of the *Hyacinth's* engines average about 23 per cent higher than those of the *Minerva* at each power (line 19), and their mean pressure reduced to the area of the low-pressure piston (or pistons) exceeds that of the *Minerva* in practically the same proportion (line 27). These figures, of course, correspond to the alteration in engine type, in the direction of shorter strokes, larger number of revolutions, and higher pressures, which has been in progress in the navy for some years past. The piston speeds at full power in the two ships are practically equal, about 855 feet per minute.

As to engine economy, it will be seen that at the two lowest powers the *Minerva* uses considerably less steam per horsepower-hour for all purposes than the *Hyacinth*. At 2,000 horsepower the comparative figures are 18.20 and 18.80, and at 5,000 horsepower 15.15 and 16.68 (see line 31). These figures correspond to the actual running

of the ships as fitted, the closed exhaust being in use in the *Hyacinth*. To form some idea of what the real advantage of the closed exhaust was, portions of each of the *Hyacinth's* runs were made with open exhaust, as mentioned above, and these portions are worked out separately. At 2,000 horsepower the extra steam used owing to the employment of the open exhaust in the *Hyacinth* was found to be 7 per cent, and at 5,000 horsepower 4 per cent, and it would seem reasonable to expect that a corresponding difference would be found in the case of the *Minerva* if her auxiliary engines were fitted in the same way.

As already mentioned, the steam used for the jackets in the *Minerva's* 2,000-horsepower trial is an estimated figure obtained from other trials, but the comparison above made remains practically unaltered if the figures for the jackets be omitted altogether.

On the 5,000-horsepower trial of the *Hyacinth* the disuse of jackets seemed to be an advantage, reducing the steam consumption from 17 to 16.68 pounds, or practically by just the amount of steam used in the jackets. They were, therefore, not used at the higher powers. No similar comparison was made with the *Minerva*, but on the run out to Gibraltar, at 7,000 horsepower, it was considered best to work without any jackets.

At 8,000 horsepower the *Hyacinth's* engines use less steam than those of the *Minerva* in the proportion of 16.88 to 18.86 (a difference of about 10.5 per cent), this being practically full power in the *Minerva* and about 82 per cent of full power in the *Hyacinth*. There is a special point about the *Hyacinth's* results at 8,000 horsepower which should be pointed out, the steam consumption being 16.73 pounds with open exhaust, as against 16.88 with closed exhaust. This result was not expected; the only cause which suggests itself is that the higher back pressure on the auxiliary engines may have made them less economical. As the *Hyacinth* was not originally designed for closed exhaust, some of the auxiliary engines will not work with the high back pressure which would occur if they were worked "closed" when the main engines are indicating 10,000 horsepower, and it would seem not improbable that the efficiency of all might be materially affected at 8,000 horsepower. It will be seen that the average power during the four hours with open exhaust was considerably less than during the eight hours with closed exhaust, but the curve is so straight (see Diagram XIX) as to show that any difference due to this cause is practically negligible.

At 10,000 horsepower the *Hyacinth* (working with open exhaust) is again more economical than the *Minerva* at 8,000 horsepower. The relation between the steam economies of the two ships is shown by the curves in Diagram XIX, which indicate that, as fitted, the *Minerva's* engines are more economical between 1,800 and 7,200 horsepower, and the *Hyacinth's* beyond these limits. At powers below 5,000, no doubt, although probably not beyond 7,000, the economy of the *Minerva* might be still further improved by the employment of a closed exhaust system.

The trial of the *Minerva* with retarders has no special interest so far as the engines were concerned, as it was carried out solely for purposes connected with the boilers. The power for which steam could be supplied by the boilers in use was not known beforehand, and it was found possible to increase it greatly after the commencement of the trial, so that the conditions as to power were by no means regular. The table gives, however, the observations made, which show that, owing to different linking-up, the pressures in the high-pressure and intermediate-pressure cylinders were more than on the 5,000-horsepower trial, and in the low-pressure cylinder much less (see lines 15, 16, and 17), and that this distribution of power is notably less economical than the former one (14.85 pounds against 13.40 pounds), and also that, for reasons not obvious, the steam used by the auxiliary plant was considerably greater on May 29 than on March 15.

The actual thermal efficiency of the engines, that is, the ratio of heat turned into

work to heat received, is given in line 36. This figure is naturally more correctly proportional to the economy of the engine than the steam consumption is, as it takes into account the different amounts of heat received per pound of steam in different cases, but the results stated by the two methods are not practically different. The *Minerva* comes first with 16.7 per cent, and the best performance of the *Hyacinth* is 15.1 per cent. When the auxiliaries are taken into account (line 37) these figures are modified, but retain the same general proportion.

Lines 39 and 40 of Table XXVI are given chiefly as matters of scientific interest. Line 39 gives the best possible theoretical efficiency of an engine similar to that tested if it worked perfectly on what has become known as the "Rankine cycle."^a Line 40 gives the ratio of the actual efficiency of the engine (line 36) to this best possible efficiency, or what has been called the "efficiency ratio." This figure shows how far each engine approaches the highest economy which can be theoretically attained by an engine of its own type working with its own steam pressure. It therefore discounts the effect of different initial pressures in comparing different engines. Compared in this fashion, the *Minerva* reaches 65 per cent and the *Hyacinth* 54 per cent.^b A comparison of the figures illustrates the fact already well proved that as the theoretical efficiency of a machine is increased so also are the difficulties of practically obtaining it. The *Minerva* can obtain 65 per cent of a possible 25.7 per cent as easily as the *Hyacinth* can obtain 53.4 per cent of a possible 28.3 per cent.

Line 27 of Table XXVI gives a figure which enables a reasonable comparison to be made between the sizes of the different engines in proportion to their work. It represents the pressure on the various pistons reduced to corresponding pressures on the area of the low-pressure piston or pistons and added together. The *Hyacinth*, of course, has a much higher reduced pressure (54.8 pounds at full power and 47.8 pounds at 8,000 horsepower, this being a part of the intention in altering the engine design in order to get machinery which would occupy less space. The actual net space occupied by the main and auxiliary engines and evaporating plant in the *Hyacinth* is 28,200 cubic feet and in the *Minerva* 29,240 cubic feet. Taking these figures in connection with the maximum horsepower measured on any of the committee's trials over a period of several hours (10,180 and 8,657 horsepower,^c respectively), they amount to 2.8 and 3.4 cubic feet per maximum horsepower in the *Hyacinth* and *Minerva*, respectively. The weights of the engines complete with shafting, propellers, and spare gear, including evaporating and electric-light plants, are given as 378.4 and 364.8 tons (see Table I), which gives 26.9 and 23.7 horsepower per ton respectively for the two vessels.

The weight of the boilers with funnels and water, and the whole of the boiler-room weights generally (Table I), are 453.8 and 557.4 tons in the *Hyacinth* and *Minerva*, respectively. Worked out on the same horsepower as in the last paragraph, the figures come to 22.4 and 15.5 horsepower per ton of boiler weights in the two vessels. It must be noted, however, that figures such as these may be very misleading; the saving in weight of machinery which they indicate may easily be more than counterbalanced by additional necessary weight in coal and water. It will be seen by figures given further on that taking machinery, boilers, coal, and water together there is

^a See report of a special committee on "Standards of thermal efficiency for steam engines," appointed by the Institution of Civil Engineers; the report was published by the institution in 1898.

^b The exhaust temperature has been averaged at 125° F. in all cases, as no exact measurement could be made of it. The figure adopted must be very close to the actual one.

^c On the contractor's full-power trial of the *Minerva* in 1896, 9,900 horsepower was developed for four hours, 9,600 being the specified figure.

very little difference between the two ships, and that the difference on the long voyage was in favor of the *Minerva*.

The combined performance of engines and boilers as represented by the coal consumption per horsepower-hour is given in line 41 of Table XXVI, and is also shown graphically in Diagram XXI. At 2,000 and 8,000 horsepower the *Hyacinth* has the advantage in this respect, while at 5,000 horsepower the *Minerva* shows best. It appears clearly from the curves that the *Hyacinth's* consumption at different powers is much more uniform than that of the *Minerva*, the latter ship being markedly more economical at medium powers than at either end of the scale. It has to be remembered, however, that the *Minerva* has seen much more service than the *Hyacinth*, and that, in general, it has been found that coal economy falls off as boilers and machinery become older. In this connection a comparison of the results of the committee's trials in respect to coal consumption with the contractors' trials of the same vessels is instructive. The comparative figures are as follows:

HYACINTH.

Date of contractors' trial.	Duration in hours.	Horse-power.	Coal per horsepower per hour.	Date of committee's trial.	Duration in hours.	Horse-power.	Coal per horsepower per hour.	Ratio.
1899.				1901.				
Nov. 6 and 7.....	30	2,146	1.72	May 30 and 31....	24½	2,049	2.03	1.18
Nov. 9 and 10....	30	7,678	1.48	June 6 and 7.....	24	4,995	1.84	.....
Dec. 4.....	8	10,447	1.59	June 25.....	11	8,116	1.84	1.24
				June 18.....	8	10,180	2.11	1.32

MINERVA.^a

1896.				1901.				
Sept. 29 and 30 ..	30	4,919	1.71	Jan. 14 and 15	25	2,142	2.15	.....
Sept. 24.....	8	8,216	2.10	Mar. 8 and 9.....	24	5,155	1.74	1.02
				Mar. 15.....	9	8,132	2.42	1.15

^a It is interesting to note that on the committee's trials in 1901 the *Minerva* did considerably better than on her special trials against the *Highflyer* in 1900, and also that the *Hyacinth's* performances as to coal were very much better than those of the *Highflyer* throughout the whole range of power. (See "Memorandum respecting water-tube boilers in Her Majesty's ships," presented to Parliament in 1900.)

There was no contractors' trial of the *Minerva* at 2,000 horsepower, but comparing the 1896 trials at 5,000 and 8,000 horsepower with those of 1901, it will be seen that after four years' active service, the coal consumption has only increased on the average 8.5 per cent. Comparing the corresponding two trials of the *Hyacinth*, the difference is 21 per cent, although the ship had not seen any service except a few special trials, and had been specially prepared for the committee's trials by thorough overhaul and trials at Devonport. At full power, the difference is still greater, viz, 32 per cent. The committee do not think that this falling off was an accident of these trials or even that it is peculiar to the *Hyacinth*. It occurred in a still more marked degree on the run to Gibraltar and back, and it is clearly noticeable in the records of the Belleville boilered vessels, which have been submitted to the committee.

Line 42 of Table XXVI gives the amount of make-up water used, in terms of the number of tons required per 1,000 horsepower per twenty-four hours. The *Minerva*, at 2,000 and at 5,000 horsepower, and the *Hyacinth* at 5,000 horsepower did not exceed 3 tons, and the maximum in the *Minerva* was 3.73 tons (at 8,000 horsepower). At 2,000, 8,000, and 10,000 horsepower, however, the *Hyacinth* greatly exceeded these figures, and it will be seen that on the outward Gibraltar run this

matter caused a practical breakdown, while on the homeward run it brought up the coal consumption to a quite abnormal figure.

The leading particulars of the runs of the *Hyacinth* and *Minerva* to and from the Mediterranean have already been forwarded to their lordships by the president of this committee. The detailed results have now been obtained and fully worked out.

This final section of the trials was divided into two parts. For the outward run, the power was fixed as 7,000 in both ships, and each ship was to continue working at this power until all the coal on board, except that in the reserve bunkers, was exhausted. The ships were in the first instance to run from Plymouth past Gibraltar to Cape de Gata and then to continue running to and fro between that point and Gibraltar until the coal was finished. The outward run was, therefore, specifically intended as a high-power endurance trial, which might give information as to the radius of action of each ship, as conditioned by their boilers, engines, and coal storage.

The homeward run was also intended to be an endurance trial, but simply in reference to power, the ships starting simultaneously from Gibraltar and steaming to Portsmouth at the highest power which they were able to maintain.

The amount of coal carried by the *Hyacinth*, in addition to that in her reserve bunkers, was 968 tons, and by the *Minerva* 1,016 tons. The coal was ordinary Admiralty Welsh coal from Devonport dockyard stores, and was of the same quality for both vessels. The stowage of the bunkers and the working out of the coal was carried out under the supervision of a staff of chief petty officers from the Portsmouth reserve under the direction of an engineer officer in each ship.

The total reserve tank storage of water, including special tanks fitted for this run, was about 140 tons in the *Hyacinth* and about 170 tons in the *Minerva*. These large quantities of reserve water were taken in order that if possible the evaporators should not be worked during the run out, so that the loss of feed water might be accurately determined. It was therefore arranged that only this reserve water should be used as make-up until it was reduced to 20 tons, after which the make-up water was to be supplied by the evaporators.

Both ships had been dry docked before starting, so that their bottoms were clean; the boilers were also clean and all machinery in good order.

Representatives of the boiler committee, consisting of the president, three members (Messrs. Bain, List, and Milton), and the joint secretaries, embarked in the *Hyacinth* and *Minerva* at Plymouth at about 2 p. m. on July 6; the ships left about 3 p. m. on the same day, and at once started working up to 7,000 horsepower. It will be convenient to deal with the two vessels separately, taking the *Hyacinth* first.

By 3.45 p. m. on the 6th, the revolutions of the *Hyacinth's* engines were 152 per minute and the horsepower 6,994, so that her trial fairly started from this time. Seventeen boilers were in use. The power was maintained steadily until a fog was encountered on passing through the Straits of Gibraltar (early in the morning of July 9, about sixty hours after starting) which necessitated slowing down for about two and one-half hours. After this, the power was again raised to 7,000, and maintained for forty hours more, until 10.30 p. m. on July 10, one hundred and three and five-tenth hours after leaving Plymouth.

The reserve water was rapidly reduced, and when it had fallen to 35 tons, the staff engineer asked to be allowed to start the evaporators on account of the difficulty of getting the water out of the tanks by the special pump which had been fitted for these trials. Two Weir's evaporators, working with exhaust steam from the auxiliaries, were therefore started at 5 a. m. on the 9th (sixty-two hours from Plymouth), and at 1 a. m. on the 10th (twenty hours later), these evaporators were supplied with boiler steam, throttled to 25 pounds pressure, instead of exhaust steam. During the afternoon of the 10th (about ninety-five hours from Plymouth), the two Normandy evaporators were started with boiler steam. During the latter

part of the trial a number of small leaks developed in the boilers, and the loss of water increased rapidly. This was especially the case after the easing down off Gibraltar in the fog, and it was at first thought that possibly the sudden easing of the engines, which caused the boiler pressure to rise sufficiently to blow the safety valves, might have contributed to this result. At 1.15 a. m. on the 11th, the staff engineer reported that the engines would have to be eased on account of the large loss of water, and the trial was therefore abandoned as from 1 a. m. All the evaporators (which together can give 96 tons of water per twenty-four hours) were working at this time, and in addition to 130 tons of water from the reserve tanks, 25 tons of drinking water had been used for boiler make-up, a total amount of 270 tons of feed water having been lost since beginning the trial, or at the average rate of 8.9 tons per 1,000 horsepower per twenty-four hours. During the last twenty-four hours of the run the rate of loss was, of course, very much greater than this. The *Hyacinth* returned to Gibraltar at slow speed, arriving there on the evening of July 11.

The total loss of feed water is made up of the amount used from the reserve tanks, made by the evaporators, lost from the feed, hot well and deck tanks, etc., as on all the trials.

Taking the run as a whole, the average horsepower from 3.45 p. m. on the 6th to 1 a. m. on July 11 (one hundred and five and one-fourth hours) was 6,913, and the total coal burned during the same time, 676 tons, being 2.08 pounds per horsepower hour, a consumption about 15 per cent greater than that obtained on the Channel trials.

The water delivered by the engines was measured for a period of four hours on July 7, and again for a similar period on July 8. The mean horsepower for the two periods was 7,020, and the water measured 17.21 pounds per horsepower hour; this included the steam used by the auxiliary engines, which were exhausting into the low-pressure receivers.

It was anticipated that the radius of action of the ship at 7,000 horsepower would be limited solely by the coal expenditure. It has turned out, however, to be limited by quite another set of conditions, depending not on coal consumption but on the excessive loss of water. The distance run when the trial had to be stopped on this account was 1,810 miles, which represented the actual radius of action of the *Hyacinth* at 7,000 horsepower. It would of course be easy to work out arithmetically a hypothetical radius of action, assuming that the ship could have continued working at the same coal consumption per horsepower until her coal was exhausted, but, especially in view of the result of the homeward voyage, the committee do not think that such a figure would have any practical value, or give a real indication of the performance of the vessel.

Apart from the loss of water, the machinery on board the *Hyacinth* worked with out a hitch on the outward voyage. Flaming occurred at the after funnel during the night of the 10th, but not at any other time. There was no difficulty in keeping steam.

The *Minerva* was a few minutes longer working up than the *Hyacinth*, so that her run at 7,000 horsepower did not begin until 4 p. m. on the 6th. Immediately after leaving Plymouth all the steam jackets were disconnected; only one auxiliary condenser was used throughout. The *Minerva* passed Gibraltar about an hour and a half ahead of the *Hyacinth*, and met with the same fog in the Straits (sixty hours from Plymouth); she had to slow down for about two hours, after which 7,000 horsepower was again maintained. On the afternoon of July 10 (about ninety-six hours from starting), a bolt of the ahead eccentric strap of the starboard intermediate engine broke, and the starboard engines had to be stopped; the port engines continued working. The accident rendered necessary the replacement of the strap by a spare one. This was smartly done by the ship's staff in about two hours, the starboard engines being stopped at 4.30 and started again at 6.45. The ship then

continued steaming at 7,000 horsepower until the total coal in the bunkers (apart from reserve) was reduced to 39 tons, when the trial was considered at an end at 11 p. m. on the 12th, one hundred and fifty-two hours after leaving Plymouth, or one hundred and fifty-one hours after starting at 7,000 horsepower. The distance covered, which represented the actual radius of action of the ship at 7,000 horsepower, was about 2,640 miles.

The mean horsepower during the run was 6,911, and the coal burnt 977 tons, or 2.10 pounds per horsepower hour.

The *Minerva* arrived at Gibraltar with 32 tons of water left in the reserve tanks, having made 12.75 tons by her evaporators on the voyage out. The total amount of feed water lost was 145 tons, which amounts to 3.33 tons per 1,000 horsepower per twenty-four hours, and corresponds very closely with the amount used on the Channel trials.

The water delivered by the engines was measured for a period of four hours on each of the five days, from the 7th to the 11th of July. The mean horsepower for these periods was 7,116, and the water measured 16.05 pounds per horsepower hour for the main engines and 1.69 for the auxiliaries. These figures are considerably higher (nearly 7 per cent) than those corresponding to 7,000 horsepower from theoretical diagrams, and throw some doubt on the policy of running without jackets at this power. It should also be noted that the distribution of power between the cylinders on this run was not the most economical, as shown by the results of the retarder trial of the *Minerva* in Table XXVI.

The 7,000 horsepower was well kept up until within seven hours of the end of the run, although the air pressure necessary to maintain this power had to be gradually increased from 0.25 to 1.50 inches. This increase of pressure was due to the choking of the ferrules and not to any forcing of the boilers, which were being worked no harder at the higher than at the lower air pressure. During the last seven hours, however, the power could not be fully maintained, and for this reason—along with the fact that the ship was very near her anchorage at the time and that fog was coming on, the trial was declared at an end, although there were still 39 tons of coal in the bunkers. Here, as with the *Hyacinth*, it is easy to give a hypothetical figure corresponding to the number of miles which could have been run had this last amount of coal been burnt by the ship while maintaining 7,000 horsepower continuously. But it appears more accurate to take the figures exactly as they stand, in which case the radius of action of the *Minerva* at 7,000 horsepower is represented by the distance already given, 2,640 miles, or 830 miles more than the *Hyacinth*.

The condition which limited the duration of working in this case was the choking up of the ferrules which are fitted at the back ends of the boiler tubes. The openings in the ferrules were found, on examination at Gibraltar, to be choked up across half or three-quarters of their area by a thick, hard brown slag, which also coated the surface of the tube plates, and which was not removed until access was gained, after cooling, to the combustion chambers.

The retarders were found in good condition at the end of the run, being only slightly burnt for about 1.5 inches of their length. A little slag was found sticking to them at the back ends; this was easily chipped off and they were all used again. No attempt had been made to move them during the run.

Although at the end of the run, as above pointed out, the ferrules at the back tube ends were badly choked up, it is to be noted that this would not in practice have delayed the ship much beyond the time necessary in any case for coaling.

The engines and boilers worked well throughout the whole run, excepting the accident to the eccentric strap bolt mentioned above. The safety valves were a little light, and some water was lost through them. The safety valves also blew heavily when the ship was slowed on account of fog in the Straits, although the silent blow-off was in use.

In reference to the speed of the two ships, it was seen from the start, both vessels working at the same power, that the *Minerva* was the faster vessel. This result, however, to whatever cause it may be due, had nothing to do with the question under consideration by the committee, and is in accordance with the contractor's trials, of which all the figures (a summary is given below) have been before the Admiralty for some time.

	Horse-power.	Speed.		Horse-power.	Speed.
		<i>Knots.</i>			<i>Knots.</i>
Hyacinth.....	2, 146	12. 10	Minerva	4, 919	17. 52
	7, 678	17. 34		8, 216	19. 60
	10, 447	19. 40		9, 902	20. 34

These figures appear to be also in entire agreement, so far as the *Hyacinth* is concerned, with the results of the special trials of that ship made in Stokes Bay in 1900.

During the stay at Gibraltar the feed-suction pipes, feed tanks, hot-well tanks, boilers, and blow-outs of the *Hyacinth* were all water-pressure tested, but no leaks were discovered except the joints on the boilers, which were made good by the ship's staff. As none of the leaks which were found appeared to be serious, it was thought well to take the ship out for a special run to test the amount of water being lost. This was done on July 16, and from a six hours' run at about 7,000 horse-power the water lost was found to be at the rate of about 56 tons per day, which was much less than had been found before reaching Gibraltar. After the ship had been under way for three hours, the engines were eased by order from the deck and the boiler safety valves allowed to blow freely, so as to reproduce the conditions which occurred during the fog on July 9; on this occasion, however, before the boiler safety valves lifted, the escape valve on the main steam pipe in the port engine room blew owing to the main-engine reducing valve failing to act. Much steam blew into the engine-room hatchway, which was a very undesirable occurrence. The rate of water lost given above was calculated from a steady three hours' run before easing, and a run of two and a half hours after easing, a fresh start having been made after the easing, and the water lost during the period when the safety valves were allowed to blow being neglected. So far as this trial went, there did not appear to be any special difference between the rates of water loss before and after the easing. But, in any case, it has to be remembered that such conditions are of possible occurrence at any time on actual service, and that it would be a very serious practical defect in a boiler if it were in any way injured by the occurrence of the maximum pressure for which it was designed.

After this run the *Hyacinth* anchored in the bay at 4.30 p. m. on July 16, and all fires were drawn except those in two boilers. It was decided to allow her sufficient time after anchoring to sweep tubes, etc., after the run of the 16th, and it was settled that the start home should not be made before 4 p. m. on July 17.

The *Minerva* arrived at Gibraltar at 12.30 a. m. on July 13, and came alongside the Mole at 7.30 a. m. that day. Steam was off the ship entirely from noon on the 14th to noon on the 15th. On the forenoon of the 14th the boilers were sufficiently cool for men to work in the combustion chambers and chip off the slag mentioned above from the tube plates and ferrules. The bridges and brickwork were found only to require touching up with fire clay for the homeward run. There was no sign of leakage in the back-ends, and the fire grates were in fairly good condition. The uptakes and smoke boxes were thoroughly cleaned and the combustion chambers scrubbed with wire brushes.

To admit of safely handling the *Minerva* out to her anchorage on the 16th, three boilers were used, viz, Nos. 1, 2, and 6.

During the 17th both vessels lay at anchor in the bay, having been told that on a signal being made at an unknown time after 4 p. m. by the senior officer at Gibraltar fires were to be lighted in the boilers not at work and the ships were to proceed to Portsmouth independently as fast as possible.

Before the ships began the homeward run a communication, as follows, was handed to the captain of each ship:

“On the responsibility of the ship’s officers, a large quantity of fresh water for boiler make-up has been taken as a precautionary measure in the double bottoms of the *Hyacinth* and in the extra reserve tanks in both ships. These latter tanks were fitted specially for the outward trial, and do not form a part of the ship’s ordinary fittings. It is to be understood that, except the amount originally allowed in each ship (about 40 tons in the ordinary reserve tanks), this is to be used in cases of emergency only during the homeward run. The evaporators, if they have not been in use before, are to be started as soon as the 40 tons mentioned have been used up, and then the make-up required is to be obtained from the evaporators. If the evaporators are unable to supply the whole of the make-up required, their use at maximum obtainable output is to be maintained, while the remaining water used may be taken from the reserve tanks.”

The condition of affairs in the *Hyacinth* on the 17th, up to the time of starting, was as follows:

5.45 a. m.—The main stop valves in engine rooms just warm to the hand. Two boilers, Nos. 14 and 17, were under steam, one at 120 pounds and the other at 105 pounds pressure. The other 16 boilers had all the grates raked clean. The generator and economizer tube-nest doors were all shut. The lower generator tubes were slightly warm to the hand. The boiler casings in way of fire-brick linings were all hot to the hand. There was about 2 inches of water in each gauge glass.

12.50 p. m.—The main stop valves on the engines were cooler than in the early morning. The two boilers under steam showed 200 pounds pressure; the other 16 boilers had the grates wooded and coaled. All tube-nest doors (both generator and economizer) shut, but most of the furnace doors were wide open. These 16 boilers now cooler than in the early morning.

3.05 p. m.—The steam gauge on the engine side of each set of main engines reducing valve showed 25 pounds pressure. Blowing engines working on both the boilers under steam. The other 16 boilers in same condition as at 12.50 p. m.

3.17 p. m.—The steam gauge on the engine side of the reducing valve of the port set of main engines showed 76 pounds pressure; the corresponding gauge of the star-board set showed 95 pounds. All cylinders being warmed up by the jackets; the average pressure in these latter, 10 pounds.

3.25 p. m.—The reduced steam gauge on both sets of engines showed 115 pounds.

3.26 p. m.—The links of port engines moved, and both engines moving ahead and astern under steam at 3.30 p. m.

3.45 p. m.—The two after stokeholds were closed down and the fans run hard. The 16 boilers not in use remained unaltered, except that a priming of oakum steeped in inflammable oil was inserted in the mouth of each furnace.

4.15 p. m.—The steam pressure in the two boilers in use was 240 pounds.

In the *Minerva* during the same period the conditions were as follows:

At 7.45 a. m. there was 20 pounds of steam in No. 2 boiler and 15 pounds in No. 1; the fires of both these boilers had been drawn overnight. The smoke-box doors were all shut in those two boilers, and the grates were being wooded and coaled. The other five boilers, which had not been in use to steam to the anchorage, had all the smoke-box doors and ash-pit dampers shut, the grates were all wooded and coaled, and the furnace doors had all catches lashed, the object evidently being to prevent the doors being opened and the boilers cooled. The water had not been changed in them after arrival at Gibraltar on July 13, and they were still slightly warm to the touch. No. 6 boiler, which was the one allowed to be under steam according to the

instructions, had 40 pounds pressure in it. The main stop valves on the engines were barely warm to the hand.

At 1.30 p. m. no steam was showing on the pressure gauges at the engines. The main stop valves on engines were so hot that the hand could not be borne on them. The main circulators were running slowly. The main condensers were quite cold. No. 6 boiler now had 80 pounds of steam, and the fires were being thoroughly cleaned. Nos. 1 and 2 boilers showed no pressure, but they were still quite hot. The other five boilers were in the same condition as in the morning, and certainly no hotter; there was about 2 inches in each gauge glass.

A little later the engines were warmed through by steam from the boiler which was in use.

At 4 p. m. the temperatures of the water in the boilers of both ships were taken and found to be as follows, the temperatures being in degrees Fahrenheit: *Hyacinth*—No. 1, 90°; No. 2, 90°; No. 3, 92°; No. 4, 90°; No. 5, 94°; No. 6, 92°; No. 7, 94°; No. 8, 96°; No. 9, 96°; No. 10, 88°; No. 11, 90°; No. 12, 92°; No. 13, 94°; No. 14, at work; No. 15, 104°; No. 16, 98°; No. 17, at work; No. 18, 109°, giving an average temperature of 94½°. *Minerva*—No. 1, 164°; No. 2, 180°; No. 3, 104°; No. 4, 104°; No. 5, 98°; No. 6, at work; No. 7, 100°; No. 8, 108°, giving an average temperature of 122½°, or 28½° higher than that of the *Hyacinth*.

The signal to start was made at 4.27 p. m. on July 17.

The 16 boilers of the *Hyacinth* which were standing were lighted immediately, and the main engines started slowly moving ahead at 4.30 p. m. The after group of boilers was connected up at 4.52, the forward group at 5.05, and the middle group at 5.09, the steam pressure being 200 pounds per square inch. By 5.20 (or fifty-three minutes from the signal) the ship was proceeding with nearly 7,000 horsepower, and at about 150 revolutions per minute. The work in the engine rooms and stokeholds was admirably carried out.

The seven standing boilers of the *Minerva* were lighted up in the same fashion, and equally without flurry or hitch. The boilers were connected up as follows: No. 1 at 4.55, No. 2 at 5.02, No. 8 at 5.07, Nos. 4 and 7 at 5.10, No. 3 at 5.12, and No. 5 at 5.15. The engines were working approximately at full power by 5.16, or forty-nine minutes from the signal, practically the same time as the *Hyacinth*.

From this time both vessels did their utmost to make all speed possible to England. The *Minerva's* records and coal measurements start at 5 p. m. and those of the *Hyacinth* at 5.20 p. m. This difference is purely an accidental one, however, as at this time the ships were close together and just reaching up to full speed.

The *Minerva's* eccentric straps warmed up several times between 5.30 and 8 p. m. on July 17, and the engines had to be eased in consequence, so that the average power for this period (estimated from the revolutions) was about 6,600. The *Hyacinth* meantime had been working at about 9,300 horsepower, and although the *Minerva* during the night reached over 8,600 horsepower, the *Hyacinth* was still about 6 miles ahead at 5 a. m. on the 18th, soon after which both vessels ran into a fog and had to slow down.

On emerging from the fog about 9.30 a. m. the ships were nearly level, the *Minerva* being slightly ahead. Throughout the day the *Hyacinth* kept up about 9,000 horsepower and the *Minerva* about 8,500, but the latter vessel had gained considerably by the evening, when another fog came on.

During the night the vessels remained close together, and when the fog lifted, about 8 a. m. on the 19th (after lasting about fourteen hours), they were again level. The *Minerva* then went on at about 8,500 horsepower and the *Hyacinth* at about 9,400 horsepower, but at these powers the *Minerva* was still the faster vessel, and went ahead until the evening, when both ships had again to slow down (a third time) for fog. The *Minerva* was more fortunate in getting through this fog than the *Hyacinth*, and was able to work again at full power by 3 a. m. on the 20th, while the *Hyacinth* could not do so until about 5.30 a. m., by which time the *Minerva* was out of sight.

The *Minerva* continuing at about 8,400 horsepower, passed St. Catherine's at 8.20 p. m. and anchored at Spithead at about 10 p. m. on July 20. The *Hyacinth* averaged 8,600 horsepower for the remainder of the journey, and passed St. Catherine's at 9.45 p. m., reaching Spithead at 11.30 p. m.

The *Hyacinth* experienced great trouble from loss of water during the whole of the run home. The 40 tons of ordinary reserve water mentioned in the communication to the captains given above was finished by 5.15 a. m. on the 20th, although her evaporators had been working practically all the time. In addition to this, it was reported at the end of the run that she had used 58 tons from the special reserve tanks. It would, therefore, appear that, as these tanks were specially fitted for this voyage and formed no part of the ordinary equipment of the ship, the *Hyacinth* could not under normal conditions have completed the full power run home at all unless she had used salt water make-up, for her evaporators were pushed to their full output throughout. The total feed water lost was 329 tons or 16.7 tons per 1,000 horsepower per twenty-four hours.

At 6.10 p. m. on the 20th—that is, when the *Hyacinth* was within four hours of Spithead—a tube burst in No. 10 boiler. A stoker was slightly injured by steam and hot coal while closing a fire door. The fires in this boiler were drawn and the boiler shut off. The damaged element was afterwards brought ashore and cut up for examination. No. 10 boiler is a wing boiler and the burst tube was the fifth from the bottom in the outer row of the wing element. The rent was on the side away from the casing; the side which would naturally receive most heat. The tube had clearly been red-hot, the softened steel stretching out under the steam pressure into a large swelling which finally burst, the actual rent being about 8 inches long and 3 inches wide at the center. The edges of the rent were drawn down quite thin and sharp, and there was every indication that the steel was of excellent quality. The lower tubes of the element, up to about the normal water level as indicated by the gauge glass, were coated internally with a thin lime deposit. The upper tubes, above the burst one, had not this deposit; they were bulged in places and reduced in thickness by stretching and wasting away. It was plainly only a matter of accident which tube split first out of several.

An examination of the boiler by the representatives of the committee on board immediately after the accident showed that both the lead plugs were gone in this element, and that the lower plugs were gone in the two wing elements on the opposite side of the boiler, and the lower plug out of the element next the one with the burst tube. The gauge glasses and their connections were found not to be choked in any way. The hole in the nipple of the burst element was found to be clear, and the amount of loose scale in the feed collector was small, and not nearly enough to suggest any temporary choking of the hole in the nipple from the cause. As far as could be seen, the other elements of this boiler were uninjured.

The engine-room register for July 20 contains the following entry, the page containing it being signed by the staff engineer: "Tube burst in No. 10 boiler, fifth row up of ninth element; water in gauge glass, three-fourths glass at time. Opened safety valves, shut off boiler, and drew fires as soon as possible."

The fact that one element was, under these circumstances, practically dry—so empty of water that several tubes in it could become red-hot (and that the very element to which the gauge glass was attached)—emphasizes most strongly the fact pointed out by the committee in their interim report, that the water-gauge indications in the Belleville boiler are entirely untrustworthy. This untrustworthiness is a most serious defect, and may even become a serious danger in the working of boilers of this type. It must be remembered that the boilers were only being worked at about 25 pounds of coal per square foot of grate—a far lower figure than in the *Minerva*—and that the conditions were in no way different from what they must always be when the ship is driven at full speed.

The lead plugs proved to be no safeguard whatever against accident in this case.

In another element of the same boiler, when it was overhauled at Portsmouth after the accident, a loose hand-hole door was found in the lower junction box in such a position as to act as a nonreturn valve on the nipple, the stud of the door forming the stem of the valve in the bore of the nipple. The element where this obstruction existed was examined in place, but showed no damage. It seems, therefore, that the ordinary variations of firing in a Belleville boiler may cause much more serious changes in circulation than even an obstruction so obvious that, if it had occurred in the burst element, it would certainly have been put down as the cause of the accident.

The amount of make-up water required by the *Minerva* was quite moderate. The 40 tons referred to in the communication quoted on page 18 was, by an oversight, exceeded, and 65 tons were used from the reserve tanks, only 19 tons being made by the evaporators. The feed water lost was 85 tons, or 4.56 tons per 1,000 horsepower per twenty-four hours.

At the higher powers, both vessels worked with closed stokeholds. The *Hyacinth* had generally an air pressure of about 0.5 inch of water, and the *Minerva's* stokehold pressures (as mentioned below) varied from 0.67 to 1.5 inches.

The figures obtained in regard to coal consumption on the voyage home, although they cannot be taken as so exact as those for the voyage out, are interesting. The run divides itself practically into sections, alternately at high and low powers, in consequence of the foggy weather. The *Hyacinth's* run of seventy-six and five-tenths hours consisted of forty-four hours at an average of 9,040 horsepower, and thirty-two and five-tenths hours at 2,310 horsepower. From the curve based on the trial results the consumption at these two powers should be 1.90 and 2.02 pounds per horsepower-hour, respectively. Taking each at its proper duration, the average for the whole run should be 1.95 pounds, while the actual consumption was 2.58 pounds, or over 30 per cent in excess. No doubt, as in the voyage out, this is largely due, both directly and indirectly, to the water losses, the water made by the evaporators accounting for only about 0.22 pound per horsepower-hour.

The homeward run of the *Minerva* divides itself in a similar fashion into forty-seven and eighty-three one-hundredths hours at an average of 8,284 horsepower, and twenty-seven and five-tenths hours at 1,875 horsepower. The coal consumption at these powers, from the curve, should be 2.45 and 2.22 pounds per horsepower-hour (without retarders), respectively. From these figures the calculated consumption for the whole voyage works out to 2.37 pounds, while the actual consumption was only 2.24. It may, perhaps, fairly be supposed that this difference is due in great part to the use of retarders, the saving from which has been sufficient to overbalance all the disadvantages due to long and irregular working and slightly inferior coal, and still to leave a balance on the right side.

In reference to the figures representing horsepower developed per ton of weights given on page 14 above, it seems important here to point out that the total difference between the engine and boiler weights in the two vessels is 90 tons out of a displacement of 5,600 tons. But in the full-power run home from Gibraltar the *Hyacinth* burned 90 tons more coal than the *Minerva*, at nearly the same average power, and used also 58 tons of special storage water. Her initial displacement due to machinery was, therefore, for the three days' run, not 90 tons less, but about 60 tons more than that of the *Minerva*. On the run out at 7,000 horsepower the coal per horsepower-hour in the two ships was practically identical so long as the *Hyacinth* could run at that power. The only thing that could have enabled her, however, to complete her trial by continuing to work at 7,000 horsepower until all coal was burned out would have been an extra weight of water carried in her double bottoms. The exact weight is uncertain, but it would have been much more than 90 tons. On neither of the two runs, therefore, could any advantage have been taken of the 90 tons of weight nominally saved.

During the run out to Gibraltar all leaks discovered throughout the machinery of

both ships were carefully noted and made good during the stay in port. On the run home the leakages from the *Hyacinth's* main and auxiliary engines and the steam pipes were seen to be very slight.

On arrival at Portsmouth the boilers of both ships were thoroughly examined and overhauled by the dockyard. In the *Hyacinth* a number of tubes were found to be slightly buckled, but none seriously except those in No. 10 boiler, which have been already mentioned. Slight leaks were found at the joints of 82 junction box doors of the generators and of 60 junction box doors of the economizers, as well as in about a dozen other places. None of these leaks could be described as more than "slight," but they existed in spite of the thoroughness with which all leakages had been stopped at Gibraltar. As the most careful examination, however, both by the ship's staff and the staff of Portsmouth dockyard, has failed to discover any other leakages, the committee are driven to the conclusion that the excessive water losses are due to the multiplicity of small leakages in and about the boilers. Further, they think that the occurrence of these leaks is inherent to the design of boiler used, as the whole of the large experience gained by the Admiralty officers since the introduction of these boilers, and the very special care and attention which has been given to this particular matter in this particular ship, has practically failed to remove them. It is, of course, possible that the steam losses due to engine leakages are greater in the high-speed type of engine than in the older one, but as to this there are no data on which to form an opinion. The results of the *Saxonia's* trials indicate, however, that the use of an increased boiler pressure, at least up to 210 pounds, does not of itself entail increased losses either at the boilers or engines.

The examination of the *Minerva's* boilers at Portsmouth showed no leaky tubes whatever and only six other leaks, all described as "very slight." The cap ferrules in all boilers were found partially closed with "bird's-nesting," similar to that found at Gibraltar, but apparently not so extensive. This had caused the stokehold air pressure on the heavy runs to rise from 0.67 inch on the first to 1.30 inches on the last, the actual pressure for the last eight hours being 1.50 inches. It has to be remembered, however, as pointed out on page 17, that an increase of air pressure rendered necessary by the choking of the ferrules is a different thing from an increase due to forcing the boilers. The boilers were no harder pressed under an inch and a half of air pressure than under three-quarters of an inch, and there was, therefore, no more likelihood of damaging the tube ends in the one case than in the other. It would have been quite otherwise had the additional air pressure been used in order to increase the rate of combustion on the grates or the rate of evaporation of the boilers. The ferrules were cleaned by the ship's staff, defective ferrules replaced, retarders cleaned and replaced, and the brickwork made good. The whole of the defects, so far as related to the structure of the boilers, were of the slightest possible kind, and no ill effect whatever seems to have resulted from the extreme and, perhaps, unexpected rapidity with which steam was raised for full power at Gibraltar, although the boilers had none of the usual fittings for increasing circulation or for heating the water at the bottoms of the boilers.

COMPTON DOMVILLE,
Vice-Admiral and Chairman.

JAS. BAIN.

JOHN INGLIS.

ALEX. B. W. KENNEDY.

JOHN LIST.

J. T. MILTON.

JOS. A. SMITH.

M. E. BROWNING,

WM. H. WOOD,

Joint Secretaries.

TABLE I.—*Particulars of hulls, machinery, etc., of H. M. S. Hyacinth, and H. M. S. Minerva.*

	H. M. S. Hyacinth.	H. M. S. Minerva.
Date of contractor's trials.....	1899	1896
Builder's name	London and Glasgow Ship-building Co.	Chatham dockyard.
Description	Second-class cruiser	Second-class cruiser.
Length between perpendiculars	350 ft.	350 ft.
Length over all	373 ft.	373 ft.
Beam	54 ft.	53 ft. 6 ins.
Displacement	5,600 tons.	5,600 tons.
Draft at this displacement {	Forward.....	19 ft. 6 ins.
	Aft	21 ft. 6 ins.
	Mean	20 ft. 6 ins.
Main engines:		
Maker's name.....	London and Glasgow Ship-building Co.	Chatham dockyard.
Description	Vertical triple-expansion ..	Vertical triple-expansion.
Number of cylinders and cranks to each set.	4	3
Diameter of cylinders {	H. P. inches..	S. P.
	Inter.....do.....	33 $\frac{3}{32}$ 33 $\frac{7}{64}$
	L. P. do.....	49 $\frac{5}{32}$ 49 $\frac{17}{32}$
Diameter of piston rods.....	48 (2 to each set).	74 74
	S. P.	S. P.
	Ins. Ins.	Ins. Ins.
	H. P. 6.613 6.622	H. P. 6 $\frac{27}{32}$ 6 $\frac{33}{32}$
	I. P. 6.615 6.556	I. P. 6 $\frac{1}{2}$ 6 $\frac{3}{32}$
	Fd. L. P. 6.620 6.620	L. P. 6 $\frac{1}{8}$ 6 $\frac{15}{16}$
Length of stroke.....	2 ft. 6 in.	3 ft. 3 ins.
	250 lbs. per sq. in.	150 lbs. per sq. in.
Where auxiliary engines can exhaust to.	L. P. receivers, evaporators, auxiliary condensers, and atmosphere.	Auxiliary condensers and atmosphere.
Boiler:		
Maker's name.....	London and Glasgow Ship-building Co.	Chatham dockyard.
Description	Belleville.....	Single-ended cylindrical.
Number of boilers	18	8
Number of furnaces	18	24
Length of fire-grate.....	5 ft. 6 $\frac{3}{4}$ ins.	7 ft.
Width or diameter of furnaces.....	7 ft. 10 $\frac{7}{8}$ ins.	3 ft. 10 $\frac{1}{8}$ ins.
Total area of fire grate.....sq. ft..	792	649
Total area of heating surface ...do... {	(Generator) 16,380	18,464
	(Economiser) 8,046	
Safety-valve pressure...lbs. per sq. in..	320	155
Tubes {	(Generator) 4 ins.	2 $\frac{1}{2}$ ins.
	(Economiser) 2 $\frac{1}{2}$ ins.	
	(Generator) 5 ft. 10 $\frac{3}{8}$ ins.	6 ft. 8 $\frac{1}{2}$ ins.
	(Economiser) 5 ft. 1 $\frac{1}{8}$ ins.	
	(Generator) 5 $\frac{1}{4}$ ins. H. $\times$ 5 $\frac{1}{16}$ ins. V.	3 $\frac{1}{4}$ ins. $\times$ 3 $\frac{1}{4}$ ins.
Pitch	(Economiser) 3 $\frac{1}{2}$ ins. H. $\times$ 4 $\frac{1}{2}$ ins. V.	
Type of ferrule fitted to tubes.....		Admiralty.
Are retarders fitted to tubes		Yes; after May 29, at request of boiler committee.

TABLE I.—*Particulars of hulls, machinery, etc., of H. M. S. Hyacinth, and H. M. S. Minerva—Continued.*

	H. M. S. Hyacinth.	H. M. S. Minerva.
Stokehold fans:		
Number.....	6	8
Diameter	6 ft. 6 ins.	6 ft.
Funnels:		
Number.....	3	2
Diameter (inside).....	7 ft. 3 ins.	Oval, 8 ft. $\times$ 6 ft.
Height above dead plates	75 ft.	75 ft.
Propeller:		
Twin or single	Twin.	Twin.
Number of blades to each	3	4
Diameter	13 ft. 1½ ins.	13 ft. 9 ins.
Mean pitch	13 ft. 3 ins.	17 ft. 8½ ins.
Immersion of upper edge.....	5 ft. 7½ ins. (for 21 ft. 7 in. draft).	5 ft. 3 ins. (for 21 ft. 7 ins. draft).
Auxiliary machinery not worked off the main engines: ^a		
Main circulating pumps	2	2
Auxiliary circulating pumps		2
Auxiliary air pumps.....		2
Combined auxiliary air and circulating pumps.....	2	
Drain tank engine.....	1	2
Hotwell pumps	2	1
Auxiliary hotwell pump ^b	1	4
Fire and bilge engines.....	4	(1 used as make up feed pump.)
Stokehold fans.....	6	8
Furnace air pumps	6	
Capstan engine	1	1
Steering engine.....	1	1
Air-compressing engines.....	2	2
Electric light engines.....	2	2
Evaporators and engines..... (sets) ..	4	2
Distillers and engines..... (sets) ..	2	2
Refrigerating machinery..... (sets) ..	1	
Coal hoists.....	2	2
Ash hoists.....	6	2
Turning engines	2	2
Workshop engine.....	1	1
Main feed pumps	3	2
Auxiliary feed pumps.....	3	4
Make-up feed pump ^b	1	
Reversing engines	2	2
PARTS.		
Main engines, with propellers, spare parts, and evaporating and distilling plants. tons.....	378.4	364.8
Boilers with funnels, spare parts, and hot water to working height; also pipes, fans, feed engines, and all boiler-room weights..... tons..	453.8	557.4

^a See Table XXIV for list of auxiliary machinery used during each trial.^b Put in for committee's trial, and do not form part of ship's machinery.

TABLE XXV.—*Boiler trials.*

No. of line.	At about 2,000 H. P.		At about 5,000 H. P.		At about 8,000 H. P.		Full power.	With retard-ers in four boilers.
	Minerva.	Hyacinth.	Minerva.	Hyacinth.	Minerva.	Hyacinth.		
1	Jan. 14 and 15, 1901.	May 30 and 31, 1901.	Mar. 8 and 9, 1901.	June 6 and 7, 1901.	Mar. 15, 1901	June 25, 1901	June 18, 1901	May 29, 1901
2	25	24½	24	24	9	11	8	8½
3	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.	In the Eng-lish Chan-nel.
4	Slight.	Moderate.	Slight.	Smooth.	Slight.	Smooth.	Smooth.	Smooth.
5	2 to 5	3 to 4	5	2	2 to 6	1 to 2	2 to 4	1
6	4	6	8	12	8	18 (for 1½ hours).	18	4
7	325	264	649	528	649	791 747	791	325
8	9, 232	8, 142	18, 464	16, 284	18, 464	24, 426 23, 069	24, 426	9, 232
9	Hand-picked	Hand-picked	Hand-picked	Hand-picked	Hand-picked	Hand-picked	Hand-picked	Hand-picked
	Welsh.	Welsh.	Welsh.	Welsh.	Welsh.	Welsh.	Welsh.	Welsh.
10	4, 601	4, 159	9, 004	9, 212	19, 695	14, 930	21, 515	9, 452
11	76. 7	69. 3	150. 1	153. 6	328. 3	248. 8	358. 6	157. 5
	Average quantity of coal used per hour							
	Average quantity of coal used per minute							
	Analysis of coal:							
12	Carbon		86. 95					
13	Hydrogen		4. 02					
14	Moisture	. 82	. 86	. 76	1. 10	. 92	. 91	. 82
15	Ash	4. 18	4. 32	3. 41	4. 30	4. 16	5. 01	4. 18
16	Oxygen and other matters		3. 85					
17	Calorific value of coal as fired	14, 679	14, 697	14, 805	14, 686	14, 578	14, 611	14, 612
18	Carbon value of coal as fired	. 98	1. 01	1. 02	1. 01	1	1	1

TABLE XXV.—Boiler trials—Continued.

No. of line		At about 2,000 H. P.		At about 5,000 H. P.		At about 8,000 H. P.		Full power.	With retard- ers in four boilers.
		Minerva.	Hyacinth.	Minerva.	Hyacinth.	Minerva.	Hyacinth.		
19	Analysis of flue gases, by weight:								
20	Carbonic acid.....per cent..	13.20	9.98	12.56	14.80	13.45	17.10		
21	Carbonic oxide.....do.....	Nil.	0.21	0.45	0.24	.29	.47		
22	Oxygen.....do.....	10.50	9.38	11.63	9.55	10.76	7.40		
23	Nitrogen (by difference).....do.....	76.30	80.43	75.36	75.41	75.50	75.03		
24	Average temperature of flue gases.....Fahr..	637 ^o	544 ^o	640 ^o	621 ^o	804 ^o	703 ^o	780 ^o	699 ^o
25	Weight of air used per pound of coal fired.....pounds..	22.9	20.5	23.3	20.2	21.8	17		
26	Weight of flue gases per minute.....do.....	1,864	1,483	3,630	3,103	7,423	4,082		
27	Air temperature on deck.....Fahr..	48 ^o	55 ^o	48 ^o	58 ^o	43 ^o	60 ^o	55 ^o	65 ^o
28	Difference between the air temperature and tempera- ture of flue gases, Fahr.	589 ^o	489 ^o	592 ^o	563 ^o	761 ^o	643 ^o	725 ^o	634 ^o
29	Mean air pressure in closed stokehold..inches of water..	Nil.	Nil.	Nil.	Nil.	.81	Nil.	Nil.	.65
30	Mean air pressure in closed ash pits.....do.....								
31	Mean vacuum at base of funnel.....do.....	.36	.36	.50	.39	.39	.43	.39	.32
32	Average feed water pumped into the boilers per hour, pounds.	39,410	40,260	79,560	86,300	156,220	147,190	190,210	83,550
33	Average feed water pumped into the boilers per minute, pounds.	657	671	1,326	1,438	2,604	2,453	3,170	1,392
34	Temperature of feed water on entering the boilers, Fahr.	61 ^o	84 ^o	96 ^o	93 ^o	95 ^o	100 ^o	97 ^o	95 ^o
35	Pressure boiler safety valves are set at...lbs. per sq. in..	155	320	155	320	155	320	320	155
36	Mean steam pressure in boilers by gauge.....do.....	110	195	144	199	148	240	277	147
37	Corresponding temperature of saturation.....Fahr..	344 ^o	386 ^o	363 ^o	387	365 ^o	401 ^o	415 ^o	364 ^o
38	Observed temperature of steam in the run of steam piping, Fahr.	338 ^o	372 ^o	360 ^o	376 ^o	357 ^o	396 ^o	401 ^o	Not taken.
39	Average wetness of steam.....per cent..	0.00	0.32	0.00	.40	0.00	4.46	6.03	do.....
40	Heat lost by incomplete combustion per minute..B. T. U..	Nil.	11,800	68,700	32,000	90,900	88,600		

40	Heat carried away by flue gases per minute.....do.....	260, 200	171, 900	509, 300	430, 000	1, 339, 000	678, 000	.....
41	Heat used in warming air through heater per minute, B. T. U.	.....	.....	.....	.....	.....	.....	.....
42	Heat corresponding to formation of steam in boilers per minute, B. T. U.	761, 000	785, 400	1, 496, 000	1, 631, 000	2, 943, 000	2, 658, 000	3, 387, 000
43	Heat expended on priming water per minute....B. T. U..	.....	800	.....	1, 800	.....	34, 600	.....
44	Balance lost by radiation and otherwise unaccounted for (by difference), B. T. U.	71, 800	47, 100	130, 000	177, 200	429, 100	167, 800	.....
45	Total heat corresponding to perfect combustion of coal per minute, B. T. U.	1, 093, 000	1, 017, 000	1, 204, 000	2, 272, 000	4, 802, 000	3, 627, 000	5, 240, 000
46	Thermal efficiency of boiler.....per cent..	69.7	77.2	68.0	71.8	61.4	73.3	65
47	Actual evaporation per pound of coal as fired..pounds..	8.56	9.65	8.84	9.33	7.93	9.39	8.28
48	Actual evaporation per square foot of heating surface per hour, pounds.	4.26	4.94	4.32	5.30	8.46	6.38	7.78
49	Equivalent evaporation per pound of coal from and at 212° F., pounds.	10.26	11.46	10.33	11	9.27	11.03	9.79
50	Weight of coal burned per square foot of grate surface per hour, pounds.	14.2	15.8	13.9	17.4	30.3	19.8	27.2
51	Heat transmitted per square foot of heating surface per hour, B. T. U.	4, 946	5, 794	4, 861	6, 016	9, 563	6, 947	8, 479
								2, 301, 400
								68.4
								8.84
								9.05
								10.34
								29.1
								10, 223

TABLE XXVI.—

No. of line.		At about 2,000 H. P.						At about 5,000 H. P.	
		Minerva.		Hyacinth.				Minerva.	
1	Duration of trial, hours	25		18		6½		24	
2	Closed exhaust or open exhaust in use	Open		Closed		Open		Open	
3	Steam jackets in use.....	All		L. P.		L. P.		All	
4	Water delivered from main engines per hour, pounds.	34,064		38,362		33,173		69,100	
5	Water delivered from auxiliary engines per hour, pounds.	4,320							
6	Water drained from jackets per hour, pounds.	608		720		682		2,150	
7	Live steam used for heating feed water per hour, pounds.								
8	Total water used by machinery per hour, pounds.	38,992		39,082		39,572		78,113	
9	Mean steam pressure by gauge on H. P. valve chest, pounds per square inch.	80		109		110		138	
10	Corresponding temperature of saturated steam, Fahrenheit.	323.3°		343.3°		343.9°		359.6°	
11	Average initial pressure of steam in port H. P. cylinder as shown by indicator diagrams, pounds per square inch.	67.5		102.3		104.3		135.2	
12	Corresponding temperature of saturated steam, Fahrenheit.	314.0°		396.3°		340.5°		358.1°	
13	Mean observed temperature in port H. P. valve chest, Fahrenheit.	322.0°		346.0°		346.0°		357.2°	
		Star.	Port.	Star.	Port.	Star.	Port.	Star.	Port.
14	Mean vacuum in main condensers, by gauge, inches.	27.8	27.0	26.5	26.4	26.5	26.4	26.7	26.0
15	Mean effective pressure, H. P. cylinder, pounds per square inch.	31.42	27.28	40.98	35.26	42.16	36.21	42.39	37.31
16	Mean effective pressure, I. P. cylinder, pounds per square inch.	11.46	10.56	11.69	12.28	12.08	12.01	21.32	20.02
17	Mean effective pressure, forward L. P. cylinder, pounds per square inch.	4.57	4.57	9.17	8.94	8.81	7.78	10.47	10.73
18	Mean effective pressure, aft L. P. cylinder, pounds per square inch.			8.59	8.49	7.72	7.29		
19	Average revolutions of main engines per minute.	82.9	84.0	101.4	101.7	100.6	99.0	110.4	111.0
20	Average indicated horsepower, H. P. cylinder.	432	380	323	279	331	279	776	689
21	Average indicated horsepower, I. P. cylinder.	352	334	246	259	252	248	874	835
22	Average indicated horsepower, forward L. P. cylinder.	320	324	253	247	241	209	976	1,005
23	Average indicated horsepower, aft L. P. cylinder.			237	235	211	196		
24	Total average I. H. P. per set.....	1,104	1,038	1,059	1,020	1,035	932	2,626	2,529
25	Collective average I. H. P.....	2,142		2,079		1,967		5,155	
26	Average I. H. P. for period of boiler trial...	2,142			2,049			5,155	
27	Corresponding pressure on L. P. piston or pistons, pounds per square inch.	15.2		18.8		18.1		27.6	
28	Steam used by main engines, per I. H. P. per hour, pounds.	15.90		18.45		16.86		13.40	
29	Steam used by auxiliary engines, per I. H. P. per hour, pounds.	2.02				2.91		1.33	

Engine trials.

At about 5,000 H. P.						At about 8,000 H. P.						Full power.		With retard- ers in four boilers.				
Hyacinth.						Minerva.		Hyacinth.				Hyacinth.		Minerva.				
12 Closed L. P.	6 Closed None	6 Open None				9 Open All		8 Closed None	4 Open None			8 Open None			8½ Open All			
84,303	83,006	77,116	{			132,622	{	416,286	{	{		123,051	{		167,000	{	70,835	
						8,227						17,867			13,500		18,605	8,235
1,142	-----	-----				2,900	-----	-----	-----			-----			2,838	-----		

TABLE XXVI.—

No. of line.		At about 2,000 H. P.			At about 5,000 H. P.
		Minerva.	Hyacinth.		Minerva.
30	Steam used by jackets, per hour, pounds	0.28	0.35	0.35	0.42
31	Total steam used by engines, per I. H. P. per hour, pounds.	18.20	18.80	20.12	15.15
32	Water supplied for make-up, per I. H. P. per hour, pounds.	0.20	0.51	0.51	0.28
33	Total water used by machinery, per I. H. P. per hour, pounds.	18.40	19.31	20.63	15.43
34	Heat supplied to main engines, including jackets, above assumed exhaust temperature, per minute, B. T. U.	628,100	.....	615,500	1,305,000
35	Heat supplied to main engines, including auxiliary engines, above assumed exhaust temperature, per minute, B. T. U.	706,440	712,300	720,800	1,431,000
36	Thermal efficiency of engines, per cent	14.4	.....	13.5	16.7
37	Thermal efficiency of engines, including auxiliary engines, based on I. H. P. of main engines, per cent.	12.8	12.3	11.5	13.3
38	Proportion of steam supplied to engines passed through feed heater (approximate), per cent.	.....	.....	.....	.....
39	Efficiency of comparative standard engines, per cent.	23.0	.....	25.0	25.7
40	Efficiency ratio, per cent	62.7	.....	54.0	65.0
41	Coal used per I. H. P., per hour, pounds.....	2.15	2.06		1.74
42	Make-up water per 1,000 H. P., per 24 hours, tons.	2.09	5.48	5.48	3.00

Engine trials—Continued.

At about 5,000 H. P.			At about 8,000 H. P.			Full power.	With retard- ers in four boilers.
Hyacinth.			Minerva.	Hyacinth.		Hyacinth.	Minerva.
0.22	-----	-----	0.36	-----	-----	-----	0.59
17.00	16.68	17.34	18.86	<i>a</i> 16.88	<i>a</i> 16.73	<i>a</i> 17.14	17.17
0.26	0.26	0.26	0.35	0.51	0.51	0.45	0.34
17.26	16.94	17.60	19.21	17.39	17.24	17.59	17.51
-----	-----	1,418,000	2,480,000	-----	2,192,000	2,947,000	1,350,000
1,571,000	1,526,000	1,580,000	2,806,000	2,605,000	2,432,000	3,276,000	1,500,000
-----	-----	14.7	13.9	-----	15.1	14.6	15.0
13.6	13.9	13.3	12.3	13.4	13.6	13.2	13.5
-----	-----	-----	-----	-----	-----	-----	-----
-----	-----	27.2	24.8	-----	28.3	28.7	25.4
-----	-----	54.0	56.2	-----	53.4	50.9	59.2
-----	1.84	-----	2.42	1.84 for 11 hours.		2.11	1.98
2.87	2.87	2.87	3.73	5.46	5.46	4.84	3.68

a After deducting wetness in steam.

REPLY OF THE MANUFACTURERS OF THE BELLEVILLE BOILER TO THE ADMIRALTY WATER-TUBE BOILER COMMITTEE'S REPORT.

ST. DENIS (SEINE), March 9, 1902.

SIR: We have the honor to submit to your notice the following observations which have occurred to us in reading the recent report by the committee on water-tube boilers on the trials of the cruisers *Hyacinth* and *Minerva*. We should be obliged to you if you would kindly place these observations before the lords commissioners of the Admiralty.

Efficiency of the boilers.—It appears to us of the greatest importance, in view of the controversies which have raged in print on the subject of the efficiency of Belleville boilers, to, in the first place, point out the fact that the committee recognize that these boilers show greater economy than the boilers under comparison with them.

The figures in line 46, 47, and 49 of Table XXV, annexed to the report, leave no doubt on this point. We give them below:

TABLE XXV.

	Minerva.	Hyacinth.
Line 46. Thermal efficiency of the boilers:		
At about 2,000 horsepower.....	69.7	77.2
At about 5,000 horsepower.....	68	71.8
At about 8,000 horsepower.....	61.4	73.3
Line 47. Actual evaporation per pound of coal under the conditions of the trial:		
At about 2,000 horsepower.....	8.56	9.65
At about 5,000 horsepower.....	8.84	9.33
At about 8,000 horsepower.....	7.93	9.39
Line 49. Equivalent evaporation (per pound of coal) at a steam and water temperature of 212° F:		
At about 2,000 horsepower.....	10.26	11.46
At about 5,000 horsepower.....	10.33	11
At about 8,000 horsepower.....	9.27	11.03

The report summarizes these observations in the following words (page 8, line 35): "The thermal efficiency of the *Hyacinth's* boilers was in each case greater than that of the *Minerva's* at the same power, and the evaporation per pound of coal from and at 212° varied, of course, in the same way. The difference is considerable at 2,000 horsepower, small at 5,000 horsepower, and very great at 8,000 horsepower."

With the object of lessening this inequality in results, and in order to better regulate the quantity of air passed through the fires in the *Minerva*, the committee had spirals of thin sheet iron (called retarders) inserted in the boiler tubes.

The result, it is true, was somewhat better, but it was not equal to that obtained on the *Hyacinth*, as stated in the report. The results on the *Minerva*, with retarders, are still notably inferior to those obtained on the *Hyacinth*, as the following figures extracted from Table XXV show:

TABLE XXV.

	Minerva.	Hyacinth.
Line 46. Thermal efficiency of boiler.....per cent..	^a 68.4	73.3
Line 47. Actual evaporation per pound of coal.....pounds..	8.84	9.39
Line 49. Equivalent evaporation from and at 212° F.....do....	10.34	11.03

^a With retarders.

It may here be remarked that these retarders are probably not unconnected with the choking of the ferrules with which the back ends of the *Minerva's* tubes are fitted, and of which mention will be made further on. As a matter of fact, the committee does not state whether similar obstructions have been experienced during voyages of the *Minerva* prior to the use of these retarders.

While these retarders increased the efficiency of the *Minerva's* boilers, without, however, making it equal to the efficiency of the *Hyacinth's*, this relative improvement seems to have been gained only at the expense of an inconvenience elsewhere.

Calorimetric tests (dryness of steam).—Before leaving this question of efficiency it will be well to say a few words about calorimetric measurements, made on the two cruisers during the trials, in order to ascertain the wetness of the steam.

The report shows that, from measurements made by a Carpenter calorimeter on the *Hyacinth* at less than 8,000 horsepower, the wetness was so small that its average value was negligible (page 10, line 60), but that when the horsepower was between 8,000 and 10,000 the proportion of water indicated by the apparatus as contained in the steam was 4.7 per cent and 6.4, respectively (ib., line 63). On the *Minerva*, on the contrary, the steam at these different horsepowers was found to be practically dry.

As a general rule, calorimetric observations are of an extremely delicate nature, but one may be certain that the readings of the instrument give results here which can not be correct.

In the first place, different positions were chosen in the *Minerva* and *Hyacinth* for making the connections between the calorimeter and the steam to be tested. In the *Minerva* the calorimeter (page 6, line 14) was connected to the steam pipe between the regulating valve and the horsepower valve chest of the port main engines; in the *Hyacinth* it was connected to the steam pipes in No. 5 stokehold on the boiler side of the separator. To render the results comparable it would have been necessary in the *Hyacinth* to make the connection near the high pressure valve chest, as was done in the *Minerva*, for it is there only that the steam, purified in the separator and "wire-drawn" in the reducing valve, is in the condition in which it is used in the engines. The calorimeter test of the steam in the *Hyacinth* was therefore made under decidedly unfavorable conditions.

Moreover, there is a contradiction between the statement that the steam in the *Hyacinth* showed more wetness at powers between 8,000 and 10,000 horsepower, and the fact that these very horsepowers are the only ones at which the *Hyacinth's* engines showed greater efficiency than those of the *Minerva*. This fact would be inexplicable if the amount of water carried over from the *Hyacinth's* boilers during the trials did in fact attain the proportions indicated by the calorimeter, for it is well known that, on the contrary, the efficiency of the engines very sensibly diminishes in proportion as the steam is wetter.

In short, Table XXVI proves more clearly still, if it is possible, that the quality of the steam of the *Hyacinth's* Belleville boilers at horsepowers of from 8,000 to 10,000 is not inferior to that of the *Minerva's* boilers. This table allows of the comparison, as regards the two vessels, of the temperature corresponding to the pressure in the valve chest of the horsepower cylinder and the temperature actually observed in this chest.

These are the figures given in lines 9, 10, and 13 of Table XXVI. First, for the *Minerva*:

Line 9. Mean pressure by gauge on the horsepower valve chest	136 pounds.
Line 10. Corresponding temperature of saturated steam	358.5° F.
Line 13. Mean observed temperature in horsepower valve chest	345° F.
Fall of temperature	13.5° F.

And the following are the figures for the *Hyacinth*

	8,000 H. P. with exhaust—		10,000 H. P. with exhaust closed.
	Closed.	Open.	
Line 9. Mean pressure by gauge in horsepower valve chest....pounds..	194	192	220
Line 10. Corresponding temperature of saturated steam.....degrees..	385.1	384.3	395.4
Line 13. Mean observed temperature in high pressure valve chest...do....	391.6	389.1	394.1
Excess of temperature.....do.....	6.5	4.8	.....
Fall of temperature.....do.....	.....	.....	1.3

Therefore in the *Minerva*, with 8,000 horsepower, the thermometer indicates a fall of temperature of 13.5°, as compared with the temperature corresponding to the gauge pressure, while in the *Hyacinth*, at 10,000 horsepower, this difference is only 1.3°, and at 8,000 horsepower there is, on the contrary, a gain of 4.8° and 6.5°. The figures for the *Hyacinth* given in this table undoubtedly show the steam to be perfectly dry, which is entirely in agreement with the greater efficiency of the engines at that horsepower.

Losses of water.—The report (p. 11, line 14 et seq.) contains the following remarks on the question of loss of water:

“The loss of steam through leaks in boilers, steam pipes, engine stuffing boxes, etc., is given in Table XXVI, line 42. It is, of course, impossible to apportion the losses to their various causes, but the results of the Gibraltar runs lead us to look upon leaks at the boilers as being responsible for any abnormal increase in these losses. On the three progressive trials of the *Minerva* the total losses were represented by 2.1, 3, and 3.7 tons of water per 1,000 horsepower per twenty-four hours, respectively. In the *Saxonia* the figure was 2.76 tons. In the *Hyacinth* they were 5.5, 2.9, and 5.5 tons, respectively, and 4.8 tons at 10,000 horsepower. The irregularities here no doubt depend mainly on the actual tightness of the boiler joints during the runs. At 5,000 horsepower the *Hyacinth's* losses came out very well, and slightly less than those of the *Minerva* at the same power; at the other powers, both lower and higher, they were very much greater, and it was found later on, during the Gibraltar runs, that on trials of greater duration they become most serious.”

Thus, during the trial at 5,000 horsepower the losses of water are a little less in the *Hyacinth* than in the *Minerva*; during the trials at 2,000 and 8,000 horsepower the losses are greater; on the runs to Gibraltar the losses are much more serious.

Attempt was made at Gibraltar, and again at Portsmouth, to discover the nature of the leaks which occasioned these losses; it does not, however, appear to have been clearly recognized at first. On the voyage out to Gibraltar a sudden slackening of speed, due to fog, had resulted in greater losses, and it was supposed that the cause might be the increase of pressure. On a special run over a free route, made during the stay at Gibraltar, the same conditions of sudden slowing down were voluntarily reproduced, with the result that the safety valves blew freely, but the tests made did not show any appreciable difference between the amount of water lost before and after the slowing down (p. 18, line 50). The importance of the losses, therefore, had no visible connection either with the speed of the engines or with the pressure in the boilers, and the question seemed involved in a certain mystery, which has been exploited to the detriment of Belleville boilers in the polemics to which the *Hyacinth* and *Minerva* trials gave rise. The question is now clearly elucidated by the experiments made with two of the *Hyacinth's* boilers at Devonport in December, 1901. The losses of water were measured with these boilers, at first in the same state in which they were at the time of the return of this cruiser from sea

service. These measurements were made during six consecutive periods of twenty-four hours each. The examination of the boilers showed that the losses were due exclusively to leaks in the joints of the hand-hole doors of the junction boxes, the faces of which did not bear truly against each other, while the asbestos rings were of irregular thickness and defective composition. The joints were remade under more normal conditions, and in a new trial, covering, like the former, a period of six times twenty-four hours, it was found that the loss had been reduced to less than one-tenth of its former amount.

The question was thus reduced to its true proportions and placed on its proper footing. We now know which were the leaky joints, and what steps are necessary to avoid such leakage. It is at present purely a question of practice, the solution of which will daily become more certain and more easy in proportion as the staff, whose attention is now awakened in the right direction, acquire more experience, and the materials prepared for the joints are better fitted for their purpose.

This elucidation, the result of the Devonport experiments, makes it easy to understand why the question of losses of water with Belleville boilers has arisen in no other navy, although every day ships of all sorts fitted with Belleville boilers accomplish, on every sea, voyages which are much longer than the run from Portsmouth to Gibraltar, thereby proving that, contrary to the opinion of the committee (p. 23, line 39), water leakage is not inherent in the very design of these boilers.

It is equally well known that it has not been judged necessary, in any navy in which Belleville boilers are used, to take any special precautions on their account, either as regards the supply or the production of fresh water. In France, for example, the apparatus fitted for producing fresh water is calculated on the same base (4 tons of water per twenty-four hours per 1,000 horsepower), whether the boilers in question are Belleville, water-tube of other types, or cylindrical.

These plain facts and results of multiple and prolonged experiments over so many fields of action ought in justice to be taken into consideration. They admit of the conclusion that the losses of water experienced during the voyages to Gibraltar are due to causes practically avoidable, and that there are no grounds for drawing therefrom the general consequences the committee have thought it their duty to deduce. The ships of all classes and all nationalities which navigate on far-distant stations, the mail steamers which are daily plying on the South American lines as well as those of Australia and the Far East, undoubtedly prove that the tightness of Belleville boilers on the longest runs and the most prolonged and rapid voyages is a practical and certain fact.

Radius of action.—This question of water loss, which, in spite of the numerous and well-known facts which we have just mentioned, is treated in the report as inherent in this design of boilers, led the committee to conclude that the *Hyacinth's* radius of action was limited, not by her coal consumption, but by her consumption of water.

But water loss is an abnormal condition, and may be avoided; we have just demonstrated this, and there is no need to go over the ground again. Consequently in order to ascertain the true radius of action of the *Hyacinth*, or of a similar ship fitted with Belleville boilers, it is necessary to consider what this radius should be, having regard to the relationship between the amount of coal consumed and the coal capacity of the bunkers, eliminating, as far as possible, all factors not connected with the boilers, since it is the question of boilers alone which is here under discussion.

But let us take first the bare figures given in the report: The *Minerva*, at 7,000 horsepower, ran 2,640 miles and burned 977 tons of coal (p. 17, lines 30 and 31).

The *Hyacinth* ran 1,810 miles and burned 676 tons of coal (p. 16, lines 63 and 49).

Such are the material facts.

On comparing these figures it will be seen that the *Hyacinth*, by burning the same quantity of coal as the *Minerva*—namely, 977 tons—would have run—

$$1,810 \times \frac{997}{676} = 2,616 \text{ miles.}$$

Therefore, comparing the radii of action corresponding to the same amount of coal burnt, the *Minerva* has an advantage of only 24 miles over the *Hyacinth*—that is to say, less than 1 per cent. This difference is almost insignificant in itself, but we shall see that if the two types of boilers had been fitted in conjunction with engines and hulls of the same efficiency, all the advantage would then have been with the *Hyacinth's* boilers, and would be proportionately greater. As a matter of fact, it is found that the efficiencies of the engines and hull of the *Hyacinth* were actually such as to diminish the radius of action of this cruiser in comparison with that of the *Minerva*.

As far as the main engines are concerned, the report shows that the thermal efficiency was greater in the *Minerva* than in the *Hyacinth* (16.7 per cent instead of 15.1 per cent, page 13, line 34).

This is a difference of 10 per cent to the detriment of the *Hyacinth*, which, all other things being equal, would have had her radius of action increased in the same proportion if the same power had given the ship the same speed. But the influence of the hull here again makes itself felt, for at the same powers the *Hyacinth* developed less speed than the *Minerva*, and this difference was very considerable.

The report (page 18, line 22 et seq.) gives the following important information on this subject:

“In reference to the speed of the two ships, it was seen from the start, both vessels working at the same power, that the *Minerva* was the faster vessel. This result, however, to whatever cause it may be due, had nothing to do with the question under consideration by the committee, and is in accordance with the contractor's trials, of which all the figures (a summary is given below) have been before the Admiralty for some time:

	Horse-power.	Speed.		Horse-power.	Speed.
		<i>Knots.</i>			<i>Knots.</i>
Hyacinth.....	2,146	12.10	Minerva	4,919	17.52
	7,678	17.34		8,216	19.60
	10,447	19.40		9,902	20.31

“These figures appear to be also in entire agreement, so far as the *Hyacinth* is concerned, with the results of the special trials of that ship made in Stokes Bay in 1900.”

Therefore the *Minerva* was faster at 4,919 horsepower than the *Hyacinth* at 7,678 horsepower, 17.52 instead of 17.34.

Is it not strictly equitable, in order to strike a fair comparison, from the boiler point of view only, that allowances should be made for elements whose influence is so considerable?

We do not insist on the fact that the *Hyacinth* had at her disposal on the run to Gibraltar only 968 tons of coal, while the *Minerva* had 1,016 tons in her bunkers, i. e., 48 tons, or 5 per cent more (page 15, line 48).

If the two ships had been obliged to use all their coal the *Minerva's* radius of action would then have apparently been increased by 5 per cent, and in fact the *Minerva's* trial was closed before her coal was exhausted, but after she had already burnt 977 tons, or more coal than the *Hyacinth* had in her bunkers at the start. The conclusion drawn from the comparison of the radii of action of the two ships was, on this account, rendered misleading at the outset, for the object of the trial was to compare the powers of the boilers and not the bunker capacities of the two ships.

In short, the gross results of the Gibraltar run, at 7,000 horsepower, make out the *Hyacinth's* radius of action to be 1 per cent less than the *Minerva's*, while if these results are looked at from the boiler point of view only, and allowance is made for the fact that the Belleville boilers were being used with less efficient engines, a

slower hull, and a smaller bunker capacity, it is found that the advantage is very greatly in their favor.

Choking of ferrules of the Minerva's tubes.—The inferiority of the *Minerva's* boilers, from the point of view of radius of action, was not only due to their large coal consumption, in spite of the use of retarders, but also to the gradual choking of the ferrules of the tubes by "bird-nesting," which was in all probability encouraged by retarders being used.

Indeed, the committee state (page 17, line 50 et seq.) that in order to maintain the 7,000 horsepower on the *Minerva* it was necessary to gradually increase the air pressure to six times its former amount (1.50 inches instead of 0.25 inch) because of the gradual choking of the ferrules, and even with that during the last seven hours of the trial the power could not be fully maintained. "The openings in the ferrules were found, on examination at Gibraltar, to be choked up across half or three-quarters of their area by a thick, hard, brown slag, which also coated the surface of the tube plates, and which was not removed until access was gained, after cooling, to the combustion chambers" (page 18, line 3).

This circumstance shortened the duration of the trial, although the *Minerva* had still 39 tons of coal in her bunkers (page 17, line 58).

Chokings of a similar nature also took place on the run home, and on arrival at Portsmouth (page 23, line 51) the ferrules in all the boilers were found partially closed with "bird's-nesting" similar to that found at Gibraltar, though not so badly, on account of the lesser duration of the run.

The committee (page 18, line 15) state their opinion that in practice the obstructions would not have appreciably delayed the ship beyond the time necessary for coaling. We may, however, be permitted to point out that the *Minerva* (page 19, line 10) arrived at Gibraltar during the night of July 12-13, at 12.30, and that it was not until the forenoon of the 14th (ib., line 13)—that is, more than twenty-four hours afterwards—that the boilers were sufficiently cool for men to work in the combustion chambers and to commence to remove the deposits adhering to the tube plates and ferrules.

The time spent on cleaning these parts is not stated, but considering the adhesive nature of the deposits and the fact that they were not confined to the ferrules, but extended over the whole surface of the tube plates (page 18, line 5), the total time occupied in cooling the boilers and in cleaning was certainly much greater than that to which, in case of necessity, a ship of war can reduce the time required for coaling. In short, the obstructions were, after only one hundred and fifty hours' steaming, sufficiently serious to prevent the power from being maintained, and to necessitate the abandonment of the trial while the ship still had coal available in her bunkers. These facts bring to light a serious fault as regards the *Minerva*, for, in practice, ships of war or commerce have frequently to make runs of much longer duration than one hundred and fifty hours.

Circulation and water levels.—During the run home from Gibraltar a tube burst in one of the 18 boilers of the *Hyacinth*. The report, in touching on this, reiterates the apprehensions and criticisms already formulated in the interim report of February 19, 1901, on the untrustworthiness of the water-gauge indications and the defective circulation, which, in the opinion of the committee, are the characteristic features of Belleville boilers.

For our part, we can only repeat the observations on these points we had the honor of laying before the Admiralty in our letter of March 28, 1901. The fact that a tube burst during the trial in question can not nullify the results obtained every day with the innumerable Belleville boilers which are in use on every sea, beneath the flags of all maritime nations.

After all, there is no type of water tube or cylindrical boiler in existence which, having been in use to any considerable extent and for any length of time, has not

occasionally met with accidents to its tubes similar to that which happened in the *Hyacinth*.

The coming down of furnace crowns in cylindrical boilers is far from being an infrequent occurrence, and the consequences are generally very serious indeed. There are, therefore, no grounds for drawing conclusions adverse to the Belleville type alone from an accident to which all types of boilers are exposed. The diversity of uses to which this boiler can be put, its well-established position, and extensive use present, on the contrary, guaranties that few other designs can offer to the same degree.

Weight and space.—The report (p. 14, line 3 et seq.) states that “the net space occupied by the main and auxiliary engines and evaporating plant in the *Hyacinth* is 28,200 cubic feet (798.5 cubic meters), and in the *Minerva* 29,240 cubic feet (828 cubic meters). Taking these figures in connection with the maximum horsepower measured on any of the committee’s trials over a period of several hours (10,180 and 8,657 horsepower, respectively), they amount to 2.8 and 3.4 cubic feet (79 cubic decimal and 96 cubic decimal) in the *Hyacinth* and *Minerva*, respectively.

“The weights of the boilers with funnels and water, and the whole of the boiler-room weights generally, are 453.8 and 557.4 tons in the *Hyacinth* and *Minerva*, respectively. Worked out in the same horsepower as in the last paragraph, the figures come to 22.4 and 15.5 horsepower per ton of boiler weights.”

The difference in weight for the complete groups of boilers is therefore 103.6 tons—i. e., the *Minerva*’s boilers weigh 22.8 per cent more than those of the *Hyacinth*’s—and comparing the maximum powers realizable per ton of boiler weight it is seen that the *Hyacinth*’s boilers can develop 44 per cent more power than the *Minerva*’s.

These differences are considerable.

The committee are of opinion that this advantage is illusory, and that the economies realized may be more than counterbalanced by additional weight of coal and water necessary (p. 14, line 18). But we have already pointed out that difficulties in regard to loss of water have arisen in no other navy, nor has it been considered necessary to provide for greater water reserve for Belleville boilers than for any other type. We have, likewise, shown that according to these very results obtained by the committee Belleville boilers possess incontestable advantages from the point of view of efficiency, and can not therefore themselves be the cause for increasing the coal supply. The important economies of weight and space shown by them stand to their credit, therefore, as an incontestable advantage.

In conclusion, we beg to be allowed to point out that since the preliminary report of the committee was published, in February, 1901, a whole year has elapsed, during which time, taking the British navy alone, about 15 large ships fitted with Belleville boilers have been added to the service, and 20 others have been kept in commission in distant seas or in active squadrons. The increasing use of these boilers appears to us not to confirm the fears of the committee, but, on the contrary, to show that in the British fleet, as in all others, these boilers daily justify more and more the confidence reposed in them. And to mention only the earlier cases in which these boilers have been fitted by the Admiralty, the cruises of the *Powerful*, and the trials carried out some months back by the *Terrible*, have shown that Belleville boilers, after six years of use on board, and after long cruises in distant seas, are always capable of rendering the best and most reliable service, and have lost nothing of their power and usefulness.

We have, etc.,

Sir EVAN MACGREGOR,
Admiralty, London, S. W.

DELAUNAY, BELLEVILLE & Co.

IV.

NOTES ON ELECTRICITY.

By Lieutenant CHARLES L. POOR, United States Navy,
Staff Intelligence Officer.

Since the publication of the last Notes on Electricity in No. XX, July, 1900, there has been a general and striking extension of the use of electricity in foreign navies, and even the more conservative foreign naval authorities are adopting it for their new vessels and are fitting better and more extensive installations in the old. The tendency everywhere seems to be toward the perfection and enlargement of existing appliances, rather than to the production of new ones, and few, if any, inventions of permanent practical value are to be noted. Electricians in general are so busy with the great commercial problems of power supply and transmission and with lighting on a vast scale, that they have given little thought to the strictly limited field of naval requirements. The notable progress and inventions have been in the matter of wireless telegraphy, the Nernst lamp, the Edison storage battery, and the use of polyphase currents. The progress of wireless telegraphy has been so great and of such importance to naval warfare that it will be treated separately. The Nernst lamp, though it promises much in economy, is too sensitive to vibration, and the glower delays its action too long for use on board ship. Accumulators are little used aboard ship, for they are heavy, troublesome, take up much room, and are affected by vibrations, and the fumes from them are objectionable. As applied to small launches and gigs they have not proved a success, though the German navy has used them to a limited extent. The new nickel oxide battery of Edison is so much lighter, however, than former cells, that its employment would modify one of the most serious disadvantages of the storage battery. It is still too expensive for general use.

The use of alternating current on shipboard has been proposed from time to time and the various advantages and disadvantages stated in the technical press, but the latter seem to so outweigh the former that the Austrian navy alone has attempted any trial of it, and that

without success. On board the coast-defense vessels *Budapest*, *Wien*, and *Monarch*, triphase alternators were installed for general service and continuous current dynamos for the searchlights only. While the installation was being completed the officials were compelled to abandon the use of the triphase current for most of the apparatus and to increase the use of the continuous current. To such an extent was this done that finally the triphase current was used only for lighting and some motors whose speed could be kept approximately constant, such as ventilators, pumps, etc. So complicated was the double wiring that upon more recent vessels continuous current alone has been resorted to.

There has been a general tendency lately toward increased voltages. At the time that electricity was first employed upon men of war, its only use was for lighting and searchlights. For these purposes a compromise voltage of 80 volts was adopted. This has served very well for a number of years, but the increasing use of electrical power has made necessary very heavy leading wires, which are more liable to damage in action, harder to install, and more liable to injury if the bulkheads should be deformed.

The demands in respect to voltage vary so much for the different uses of the current that it is difficult to select a compromise that will best serve all. For projectors a voltage not in excess of 80 is desirable. Greater voltages require an increase in the choking power of the rheostat and a consequent loss of energy. For electric lights, general practice ashore and in the merchant marine afloat has decreed 110 volts to be suitable. Greater voltage is possible, but as the fragility of the lamp varies as the square of the voltage, we would very soon have a lamp unsuited for the shocks undergone in a vessel. For motors of course the higher voltages are most advisable, and we obtain much better results, at the same time reducing greatly the size and weight of the leads. But here we are confronted by the difficulties of careful insulation aboard ships, and while it is possible to carry 250 volts, yet it would seem that 200 volts would be a safe working limit. For a while this difficulty was solved in some navies by having a double installation—one for the general service, the other for the turret-operating service. For example, on the *Jauréguiberry*, of the French navy, the main current was at 80 volts, while the turret circuit was at 160. The complications and disadvantages of this system have caused it to be abandoned in all new vessels. To-day the general practice is to employ a single voltage, and the following increased voltages have been adopted by the various navies: France, 120 volts (for the new battleships); Russia, 110–120 volts; Germany, 120 volts; Italy, 110 volts; Great Britain and Japan, which are conservative in electrical matters, retain their voltage at 80.

The British Admiralty has, however, taken a decided step in advance

in electricity, and in the new armored cruiser *Hogue* has installed a very complete system for the electrical operation of all of the auxiliaries. A corps of electricians has been formed, and there is an evident intention to go much more extensively into the subject.

Progress and improvement has been noted during the year in foreign navies in the following respects:

DYNAMOS AND ENGINES.

There has been a general tendency toward increase in the size of dynamos and a consequent reduction in number, though it is not considered advisable by many to reduce the number of units below 4 in large vessels. This is based upon the theory that a dynamo will stand for a time an overload of one-third its normal power. This being the case, any three of the dynamos could supply the total output in case of an accident to the fourth. It is possible to have an overload of one-half, but to allow this the cost of the dynamo is increased more than advisable. With the increasing size of dynamos, it of course follows that in port only a small portion of the output of a single machine will be required, except in those vessels whose auxiliaries are entirely electrically driven. For this reason, in several vessels, for one or more of the larger units have been substituted two or more of less output than the larger dynamo. The different arrangements in various navies may be noted in the table of Mr. C. Laurentis's valuable article on the Transmission of Electric Energy on War Ships, reprinted from the *Rivista Marittima* of December, 1901, and here appended.

Mr. Laurenti also discusses the question of the separation and location of the dynamos. To his conclusions must be added the evident fact that the dynamo room should be placed as near as possible to the boilers to avoid length of steam piping.

The engines for dynamos are almost entirely of the compound vertical inverted type. These engines run at from 275 to 400 turns per minute, the latter being about the maximum with the ordinary type. Steam separators are, of course, absolutely essential with these engines.

A new and successful type is the Willans inclosed engine, in which all the reciprocating parts are incased in a tight bath of oil, affording excellent lubrication and at the same time preventing waste of oil.

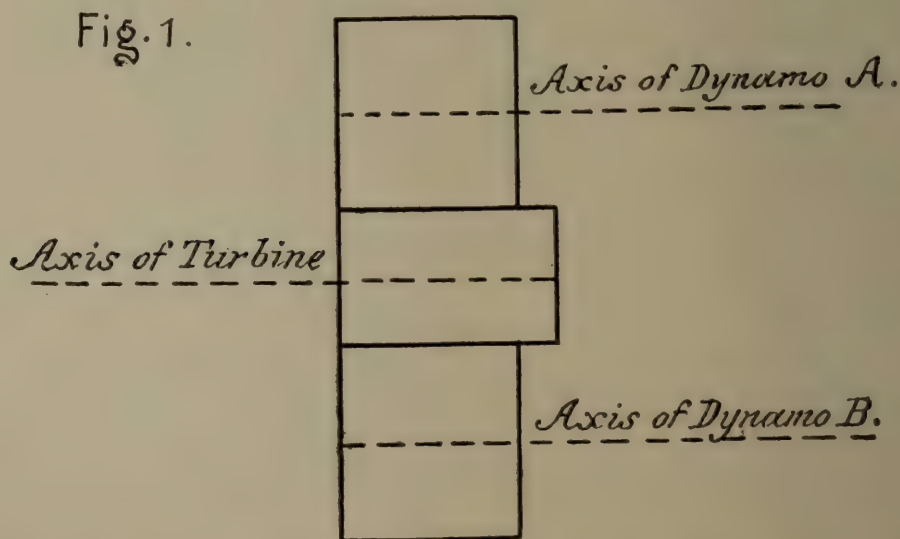
In another type (the Delaunay-Belleville) the lubrication is fed under pressure from a pump worked from the shaft of the engine. The moving parts are also inclosed, to avoid dust and save oil. Both of these types require almost no care, a great advantage on shipboard.

The question of petroleum engines for dynamos has been agitated, but without much result. Though it would unquestionably be advantageous to be able to haul all fires in port and to work all auxiliaries

by electricity from petroleum-driven dynamo machines, yet there is a strong prejudice against the storage of this inflammable material on board men of war. Also it would be necessary, in winter anyway, to have steam on for heating purposes, and, finally, petroleum motors are heavier and less economical than steam motors for the same purpose.

Steam turbines have been successfully employed for some time in shore stations for running dynamos, and are beginning to be introduced on shipboard. The chief objection to them has been the excessive speed at which they run. Turbines are better suited to large units than to small ones. Experiments have been conducted on the French torpedo boat No. 243, in which was installed a propelling turbine developing 1,200 horsepower at 1,800 revolutions. M. Rateau, engineer in the French mining corps, who has conducted these experiments, from their results, believes that it will be possible to construct turbo-dynamos supplying from 80 to 120 kilowatts at about 3,000 revolutions.

These turbines are direct-coupled. With the single-disk De Laval turbine, a few of which have been tried on shipboard, gearing has been introduced between the turbine and dynamos, the general practice being to engage two dynamos by the single-gear wheel of the turbine so as to form a couple and balance the reaction (fig. 1).



The great speed (from 3,000 revolutions for small to 12,000 for large engines) and delicate construction of these turbines present great difficulties, and the gyroscopic action of the disk when disturbed by the rolling of the vessel sets up severe strains in the shaft. These strains are much less in the slower multiple disk engines of Parsons or Rateau, but in any case it is advisable to install them with the axis in a fore-and-aft direction.

The gain with the turbine is in decreased weight, coal consumption, space, and vibration. At the central station in Cambridge, England, equipped with Parsons turbines, at full load (600 kilowatts), the steam

consumption was 24.25 pounds per kilowatt, and with a load of 100 kilowatts it rose to 33.07 pounds per kilowatt an hour. From the mean of six measurements it was found that with irregular loads the mean steam consumption would be 28.2 pounds per kilowatt an hour. Assuming eight-fold evaporation, this would give a coal consumption of 3.52 pounds an hour per kilowatt, or for one I. H. P. at the motor shaft 3.52 pounds an hour. Other investigations made elsewhere have given even better results (a steam consumption of from 21.5 to 22.5 pounds an hour per kilowatt). These contrast most favorably with compound engines. It will be observed, however, that reduction of load means a greater proportionate steam consumption than with the compound engines. It has also been found that turbines require, to insure economy, a very good vacuum. It is claimed that a saving in weight of parts of about 40 per cent may be effected by their use.

The substitution of cast steel for cast iron in recent dynamos and motors has effected a saving in weight of about 30 per cent.

AMMUNITION HOISTS.

This, one of the earliest applications of electricity on shipboard, has been more universally extended than any other, and owing to its manifest advantages of absence of heat, possibility of distant control, speed, and freedom from noise has almost entirely supplanted any other form of power for this purpose. The types and varieties of hoists are infinite, owing to the varying requirements of installation and delivery. The increasing rapidity of gun fire has taxed the capacity of the hoists very much, and in large vessels it has become a serious problem how to install an efficient service without excessive number of hoists and stations. There has also been complaint of late of danger from sparking in the motors installed directly in the magazines and handling rooms. This is a matter requiring attention, for, from the nature of the service, it is not always possible to install the motors outside of these compartments.

VENTILATORS.

The use of the electric fan for ventilation of quarters and small compartments has become so universal as to require no comment. In regard to large blowers and ventilating fans, the use of electricity has gained very great headway and has been generally adopted by most navies, except in the engine and fire rooms, where there is still some opposition to its use. The objections offered are: Electric blowers are not easily controlled as to speed; the heat in these compartments is bad for the armatures and coils and liable to burn them out, and when the blowers are so near the boilers, the original source of energy, the transmission of steam to the dynamos to be converted into electrical

energy, then to be returned to the blower to be converted into mechanical energy, is not good engineer economy. Notwithstanding these reasons, several ships are installing electric blowers, with success, in their fire and engine rooms, more extensively in the latter than in the former. For example, in the French navy the *Charlemagne*, *Gaulois*, *Iéna*, and *Suffren* have them in the engine rooms, while the *Iéna* and *Suffren* only have them in the fire rooms.

PUMPS.

The use of electricity for pumps is generally increasing, especially in its application to large centrifugal pumps for the removal of water. The Russian, French, and Italian navies in particular have adopted this system. (See Naval Constructor Laurenti's article appended.) It is possible to use these pumps in all cases where great pressure or suction are not required. Their economy in weight, coal, and cost would warrant such use. Even for fire service such pumps would be available, for they can be constructed to throw water under favorable conditions to a distance of 50 yards or more under 5 to 6 kilograms pressure. Electric pumps are generally used for the cooling water in installations for cooling magazines, the air being forced by electric blowers through a refrigerator cooled by water circulation.

WINCHES AND HOISTS.

A great advance has been made in the application of electricity to winches and hoists located on deck, in exposed places, and at long distances from the boiler. Ash hoists, coaling winches, cargo winches, and boat winches have come into very general use in the new ships, both men-of-war and merchant vessels. The North German Lloyd Steamship Company has had very great success with electric cargo winches and loading cranes. The latter showed decided advantages over hydraulic cranes on sister ships, and their operation could be intrusted to entirely unskilled labor. By an ingenious arrangement (similar to searchlight controls) of the crane lifting and turning motor rheostats, one lever was made to operate both. When this lever was in the middle horizontal position the crane was normal to the ship's side, with hook of the fall half way up. Elevating or depressing the lever raised or lowered the hook; turning the lever in azimuth swung the crane in or out. These operations could be performed simultaneously. The stroke was regulated by defined resistances to give seven different speeds. Fig. 2 shows a successful type of 15 horsepower continuous current coaling winch as used in the German navy. It is very similar in type to those used for boat hoists, deck winches, etc. These

auxiliaries being mounted in exposed places on deck must be carefully inclosed and protected from dirt, coal dust, and water.

It is the practice now to have in installations for varying loads double motors arranged with a common armature and fitted with connecting posts at the ends, on the right and left sides, for connecting either in series or parallel according to the work required.

In the use of electricity for boat hoists we encounter the necessity for relatively great power and slow speed. This compels motors that are nearly twice as heavy and expensive as steam winches. Also they make great, even though momentary, demands upon the electrical output of the ship, especially in harbor service. A battleship boat hoist, for example, would consume ordinarily about 32 kilowatts. This in most vessels would require the starting of a special dynamo, one of the battle units, to operate it safely. Where dynamos can be joined in parallel we may of course use two smaller units. These disadvantages are no longer of so much moment in the new large vessels with powerful electric plants, and their advantages of instant operation, economy of steam, and greater safety in battle have led to their adoption in several vessels. (See description of their use on the German cruiser *Agir*.)

TURRET TRAINING GEAR.

Hydraulic gear, so long popular for turret mechanism, is rapidly giving way before the superior advantages of electric train, and even Great Britain, always most conservative in this respect, has ordered the adoption of electricity for turrets in the new vessels laid down, though as a reserve substitute for hydraulic and hand power. The *Rivista Marittima* for October, 1901, gives a list of vessels whose guns and turrets are electrically controlled, which list, revised and added to, shows the following number of ships with electric gun apparatus: France, 33; Germany, 4; Russia, 7; Japan, 2; Italy, 6; Argentine, 4; United States, 17; Brazil, 2; Chili, 2; Sweden, 4; Austria, 4. To this should be added practically all the new turret vessels under construction outside of Great Britain.

CAPSTANS.

The great distance of the capstan from the boilers has rendered this type of auxiliary particularly wasteful of steam, and by the heating effect of it and its piping a constant source of discomfort and danger in the crew's living spaces. Naturally the application of electricity to remedy this was soon put into practice, but the results have not been altogether successful. The work to be performed is of the severest nature, and sudden and very heavy strain must be put

upon the motor; also, as in boat winches we must have great power with slow speed, which entails almost twice the weight and cost of a steam engine. The best known example of electric capstan was that installed in the German ship *Ægir*. Fig. 3 shows this type. The following notes on its operation, from a lecture by Naval Architect W. Geyer before the German Shipbuilding Society, are of value, and supplement those in No. XX, page 251, of these notes:

The capstan of the *Ægir* was fitted with a throttle resistance regulator. In the criticism of this installation it was stated that in measuring the expenditure of the power used by the motor it was found to be 100 per cent greater than that required for a steam capstan under similar conditions. The motor, however, notwithstanding this double load, carried it because it was so strongly built. This unexpected consumption of energy by the capstan is stated in the report to be due to the fact that the primary dynamo had not sufficient power and that in order to break the anchor out it would be necessary to install a second dynamo.

Unfortunately the electric capstan was for this reason replaced by a steam capstan, although it is now known that by a very simple alteration in the switch connections of the capstan motor, whose power was not by any means exhausted, the electric capstan would have proven adequate for the following reasons:

The pulling power of the motor is proportional to the current strength lead to it. If we double the current strength the pulling power of the motor will be doubled. This, however, is not unlimited, but depends upon the temperature to which the copper armature bars are raised by the current. The regulating resistance controls the current admitted to the armature by throttling its intensity within certain limits.

The energy supplied to the *Ægir's* capstan motors by the two steam dynamos run for that purpose was not utilized; the greater part was swallowed by the regulating resistances and uselessly transformed into heat. If the dead resistance is replaced by a second working resistance the energy that was previously wasted in heat can be utilized for work. That is, double the work may be obtained for two motors connected in series than from one motor with the throttled resistance, with the same electrical energy. This arrangement is in practical use everywhere. (See above, under "Winches and hoists.")

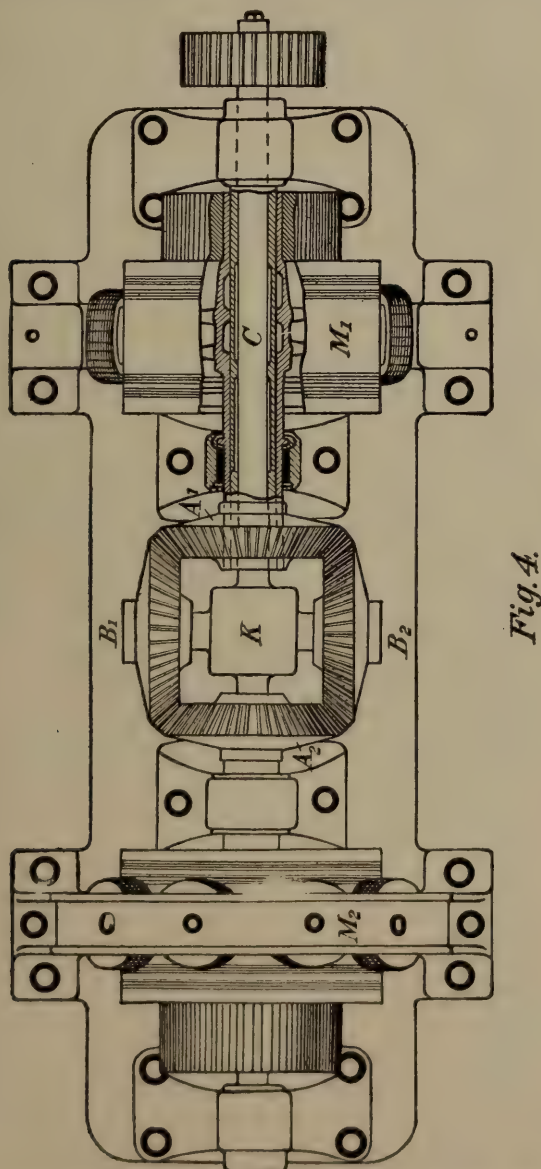
After-deck and stern capstans have been installed with some success in several vessels.

STEERING GEAR.

Under this head are to be considered electric steering gear and the electric control of steam steering gear. Just as in the case of the capstan, the great distance of the steering engine from the boilers has rendered steam gear very wasteful indeed, and the engine and piping have been a source of discomfort and danger to the after part of the vessel. To obviate this two or three types of electric steering gear have been installed on ships, especially in the Russian and German navies. The Portuguese cruiser *Reinha Amelia* is fitted with a French apparatus, originally designed for the battleship *Iéna*, but not approved for that vessel, which has proved thoroughly successful.

The steering engines for the German cruiser *Ægir* and the Russian

cruiser *Diana* were furnished by the Union Electrical Company of Berlin. Notes upon the operation of the gear of the *Aegir* will be found in No. XIX of these notes, page 251, and also in the notes upon the operation of the *Aegir's* installation here appended. The following description of the apparatus, condensed from Schiffbau, Nos. 22 and 23, 1901, will explain the general construction and principle of the gear as applied to the *Diana*. The arrangement is based



upon the application of differential running. In fig. 4 it is seen that the pair of bevel gears A_1 , A_2 are revolved by two permanent motors M_1 and M_2 . This transmitted motion to the shaft C varies as one-half the difference between the speeds of M_1 and M_2 .

When the rudder is at rest amidships M_1 and M_2 revolve at 300 revolutions per minute. To move the rudder the revolutions of one motor are increased to 400, while those of the other are reduced to 260, whence the shaft C turns at 90 per minute in the direction of

revolution of the faster motor. Thus, to control the rudder we have only to vary the relative speeds of the motors.

Fig. 5 shows the electric connections. The two armatures M_1 , M_2 are in parallel, while the field magnets F_1 , F_2 are in series. Resistance L is placed in the circuit by the switch U to connect with either end of the field coils. This switch or commutator is placed in the steering standard to be described later. There is an additional resist-

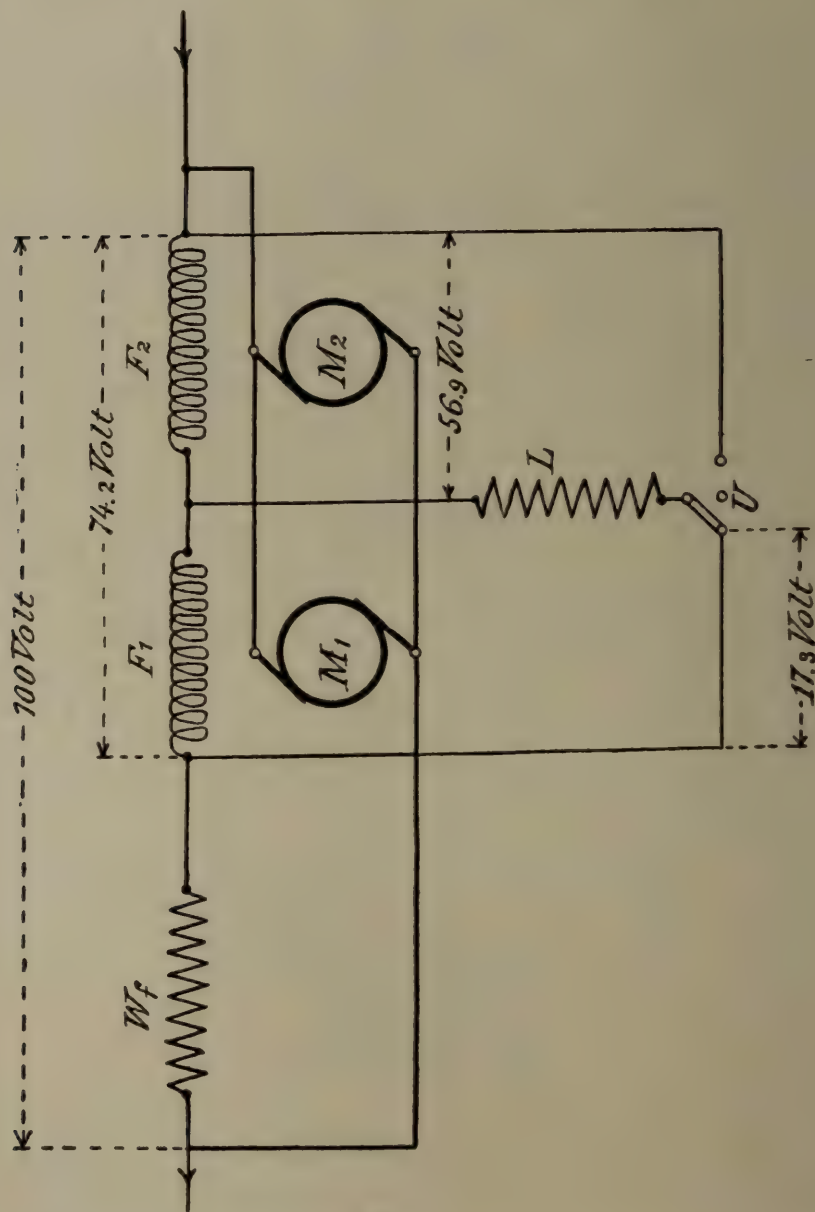


FIG. 5.

ance to be shunted into the field circuit, W_f . The resistance of the two field coils is the same, 2.7 ohms. Resistance of L is 1.8 ohms, so that to turn the rudder starboard or port the strength of the current will be increased in one and reduced in the other of the two circuits F_1 , F_2 , in parallel. In Fig. 5 if "U" is placed to the left the aforesaid condition will prevail, and the difference in strength of the two currents

resistance to the parallel connected armature. At the contact plate of the shunt there is an automatic switch to break circuit in case of disturbance in the field, thus avoiding the possibility of burning the field armature. The electromagnet of this switch is in series with the field circuit, and as long as the current strength does not exceed a certain limit the lever of the magnet is held in place, but it is drawn back by its spring in case there is any unforeseen decrease in current, thus stopping both motors. The resistance coil L , fig. 5, is arranged in two connections, one part going to the steering standard, the other, L_1 L_2 , to the end switches. This is necessitated by the lack of space for proper resistance in the five steering standards, and to the varying distances and consequent varying loss of voltage to these standards,

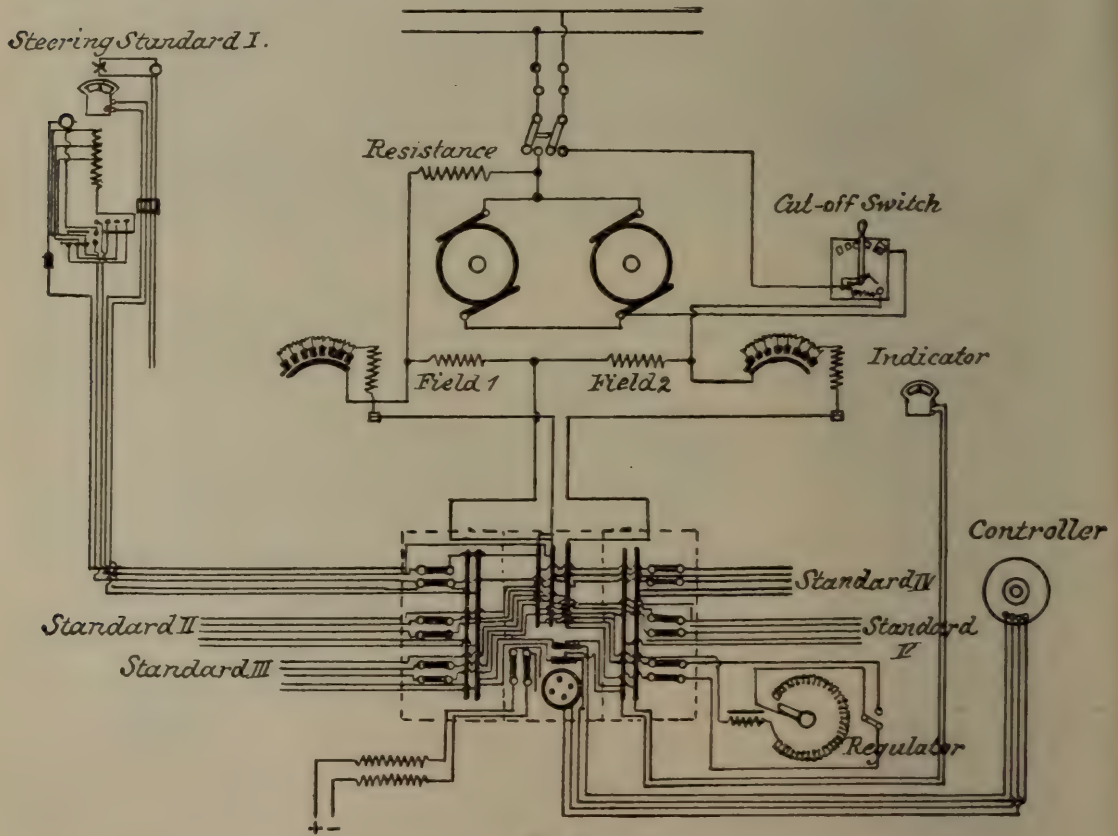


FIG. 8.

requiring that the resistances in the standards be used to equalize the voltages. Thus the rudder can be shifted with equal speed from each standard. The resistance L in the steering standard is connected to a further resistance coil L_a at the second contact to prevent sparking. For the same reason end cut-offs L_1 and L_2 are so provided. The end cut-offs are mounted on the spindle of the rudder quadrant, and prevent the rudder from going too far when put hard over, as they act automatically to cut out the current if it is not switched out in time by the steering standard.

A regulator is attached (fig. 8) to the motors and has switch connection with the motor field. The resistances are regulated in many steps,

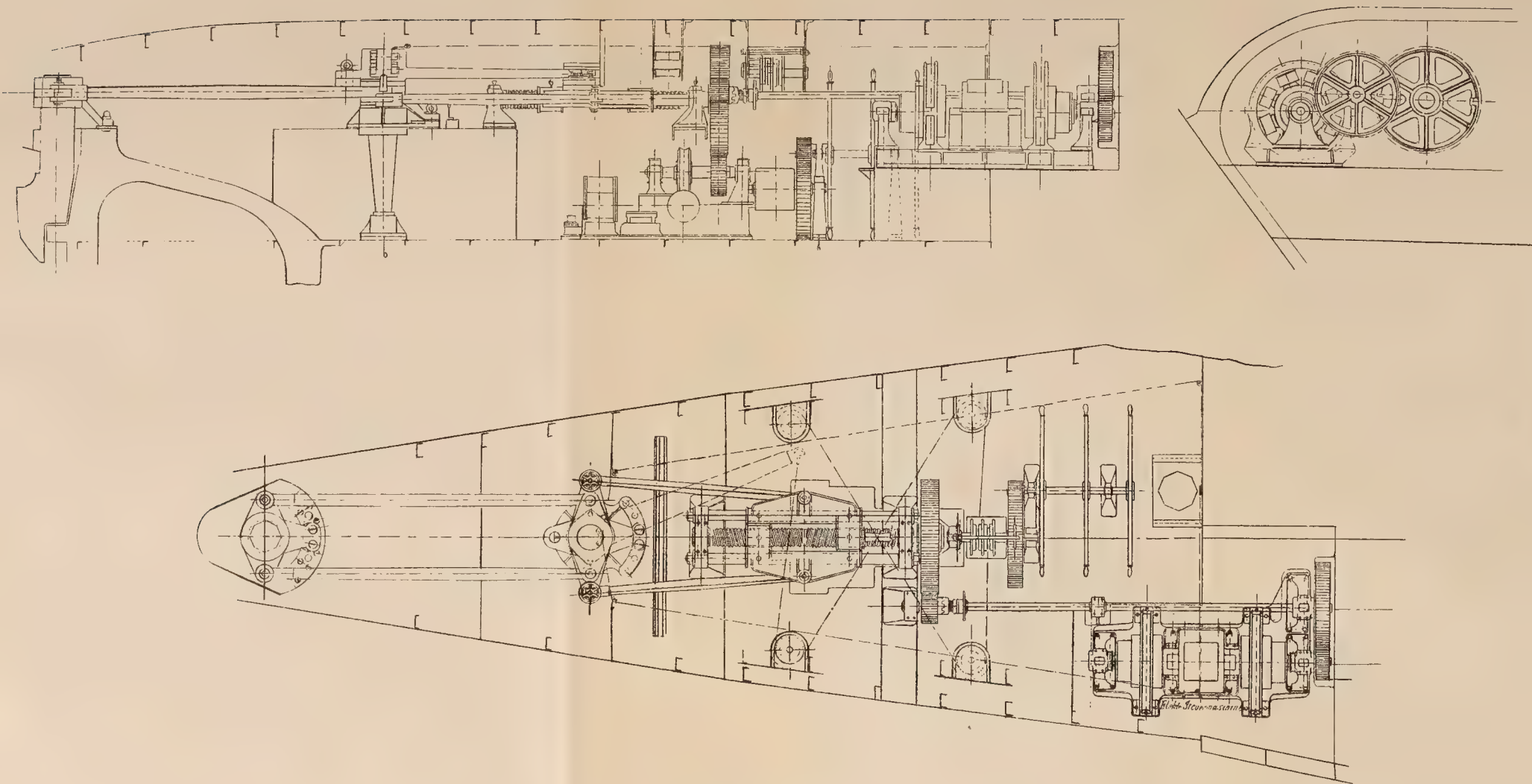
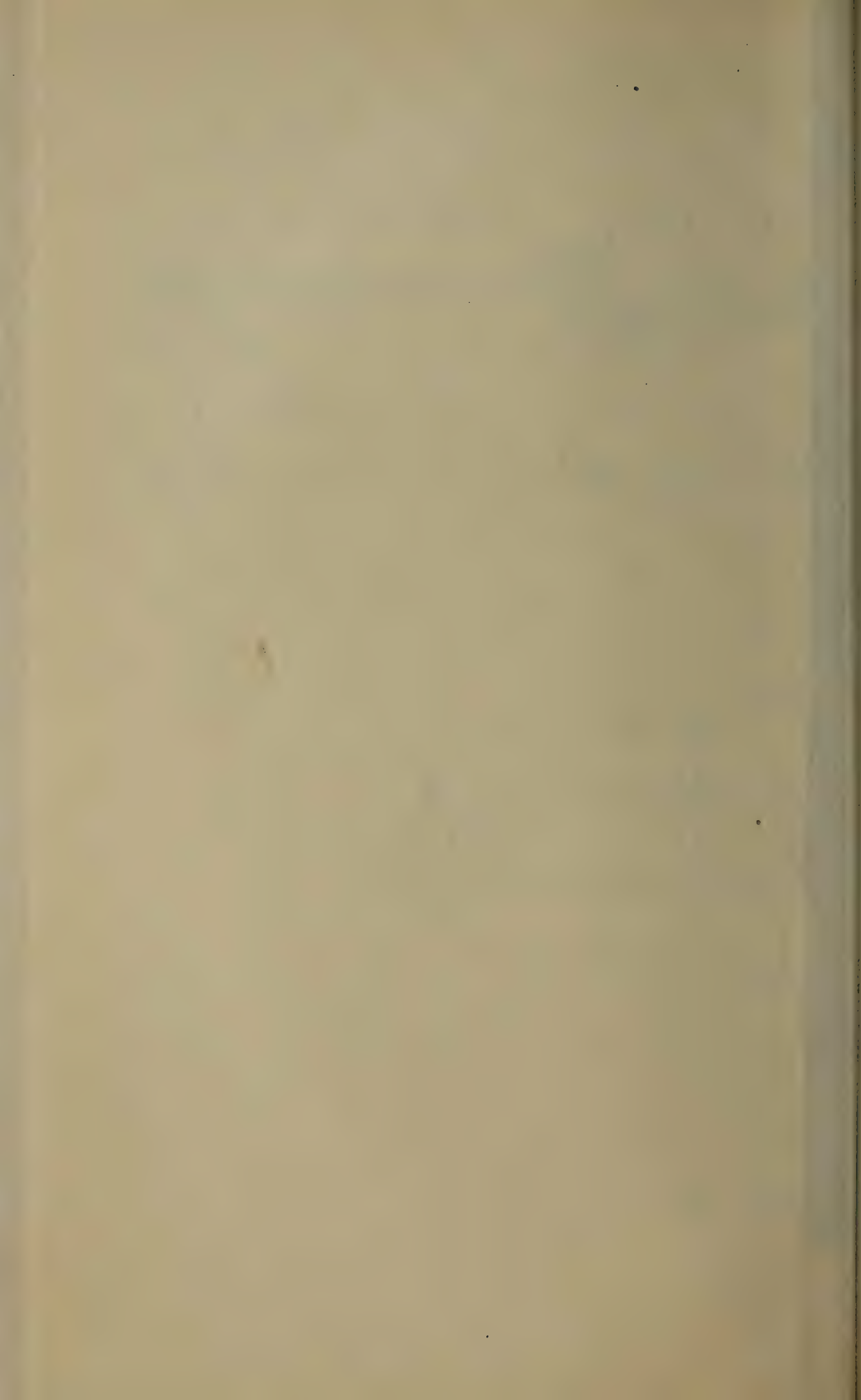


FIG. 7—ELECTRIC STEERING GEAR, RUSSIAN CRUISER "DIANA."



much more so than in the stands, as the latter only control slight differences in the number of revolutions. The attempt to control the number of revolutions by means of the commutator brushes is abandoned, as sparking of the brushes is only avoided by having them in a fixed position independent of the speed of revolution. The regulator is adjusted and permanently fixed. Readjustment is only necessary with a difference of temperature such as to influence the uniform motion of the motors.

A third circuit connects the steering standard to the rudder-position indicator. The latter is built in the steering standard and serves to control the position of the rudder.

The steering standard is operated by moving the lever to port or starboard and holding it in the position until the rudder indicator shows the desired position. To bring the rudder to rest the lever must be released. Springs fitted in the foot of the standard bring the lever back to zero position. The resistances, contacts, etc., in the standard are wound double in the pedestal to prevent influence upon the compass. The rudder indicator is at the head of the pedestal, with a scale illuminated at night from behind. The separate steering standards have cut-outs and are usually all cut-out except that in use.

The rudder position indicator is connected to the apparatus in the steering room, which latter is operated from the rudder head by a wire rope connection, an arm moving thus with the rudder over a series of 80 contacts, 40 for each side, thus adding or decreasing resistance and affecting an indicating voltmeter in the bridge standard. It is claimed that the errors of indication are not greater than one degree.

As noted (see page 315), this type of gear gave rise to various complaints, and the company have manufactured a new design, dispensing with the entire differential mechanism, having but one motor, which is reversed when the rudder is to be moved in the contrary direction. By this system the full power of the motor is used. When the rudder is amidships no current is used and we save the expenditure of the constantly running differential motors. Starting, regulating, and reversing this motor is simple, a dynamo being placed in the circuit between the rudder motor and the branch junction to the electric mains. This dynamo serves to add to the potential or to oppose it as needed, without affecting the general mains. The variation of potential of this additional dynamo is regulated by changing the magnetic field. The connections are shown in fig. 9. When the rudder is amidships the additional dynamo gives a potential of minus 110 volts, which completely annuls the current of plus 110 volts from the mains. By decreasing the negative potential of the extra dynamo there is a positive potential taken to the rudder motor, which amounts to 110 volts when the additional dynamo has zero potential. When the field of the additional dynamo is reversed the potential to the rudder motors is

110 volts plus the 110 volts of the additional dynamo, or a total of 220 volts. The additional dynamo takes the place of the starting and regulating resistances.

The steering standard on the bridge is apparently complicated, but really quite simple. This standard contains the regulating resistances to alter the field magnets of the extra dynamo and a reversing switch for the same. This reversing switch throws into circuit the field coil magnets that were otherwise without current. Objection in this arrangement to the necessity for an additional dynamo is modified by the fact that it need be but one-half the size of the rudder motor, having the same current strength with half the potential. This permits great speed, and it is light and very small. The Pfatischer or Leonard system of electric steering gear as applied to Russian men-of-war is somewhat similar in principle to the foregoing in its operation upon the field coils, with the essential difference that it is not applied directly to

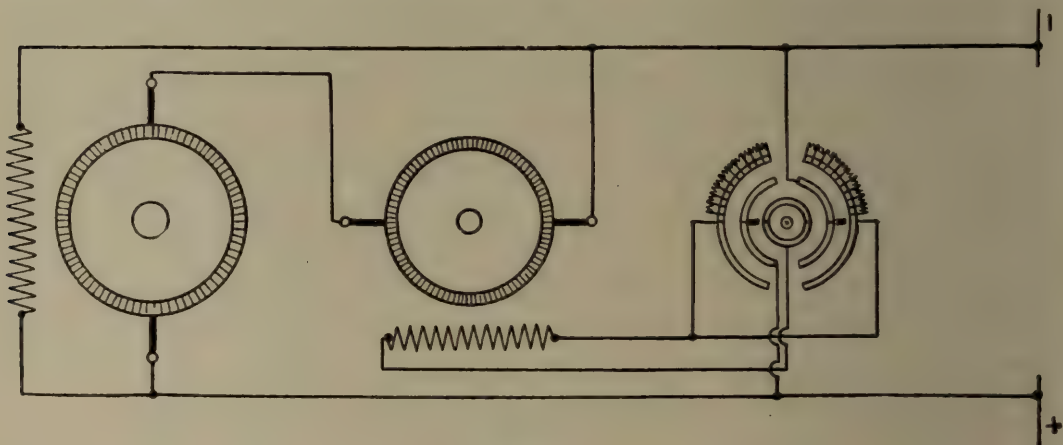
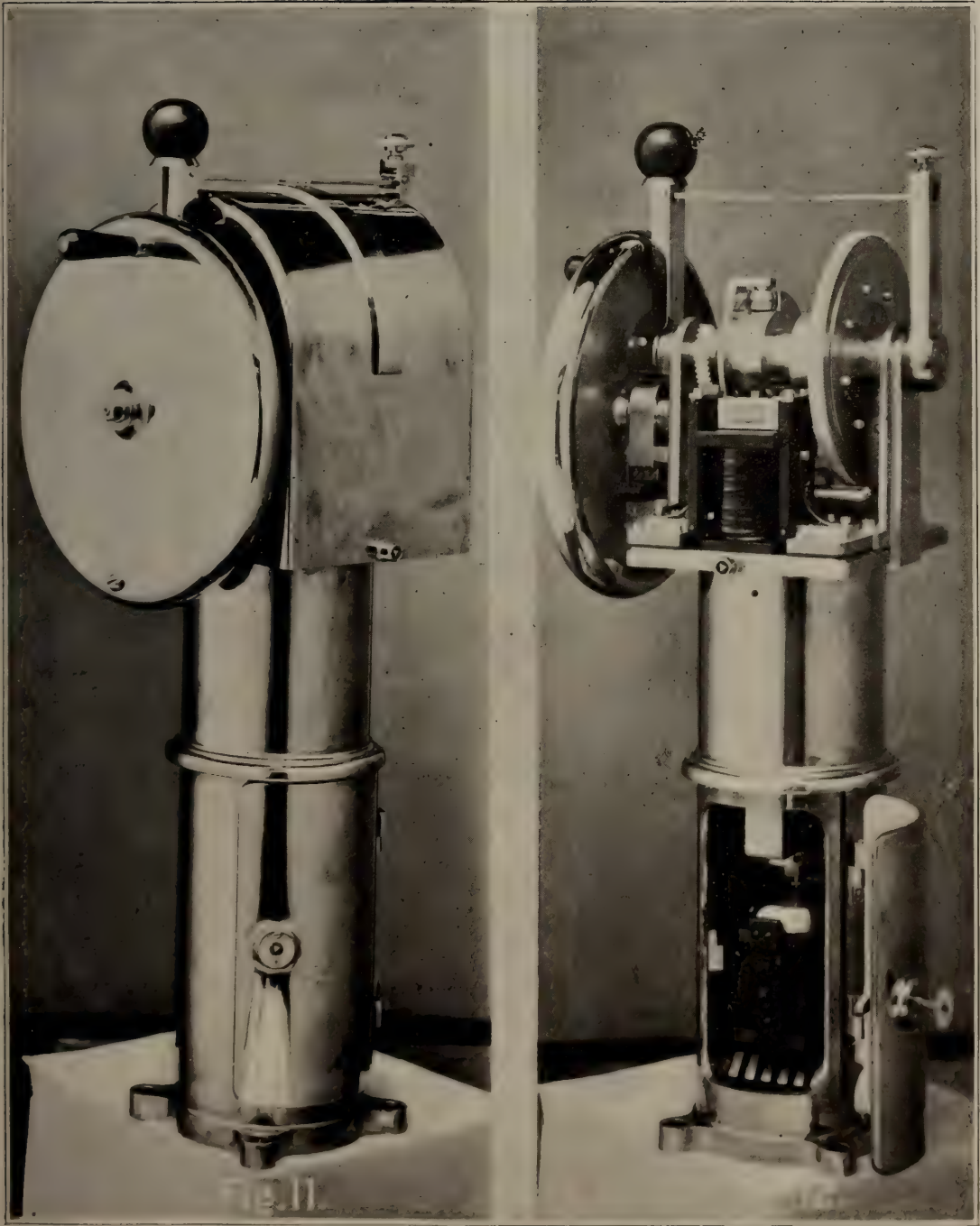


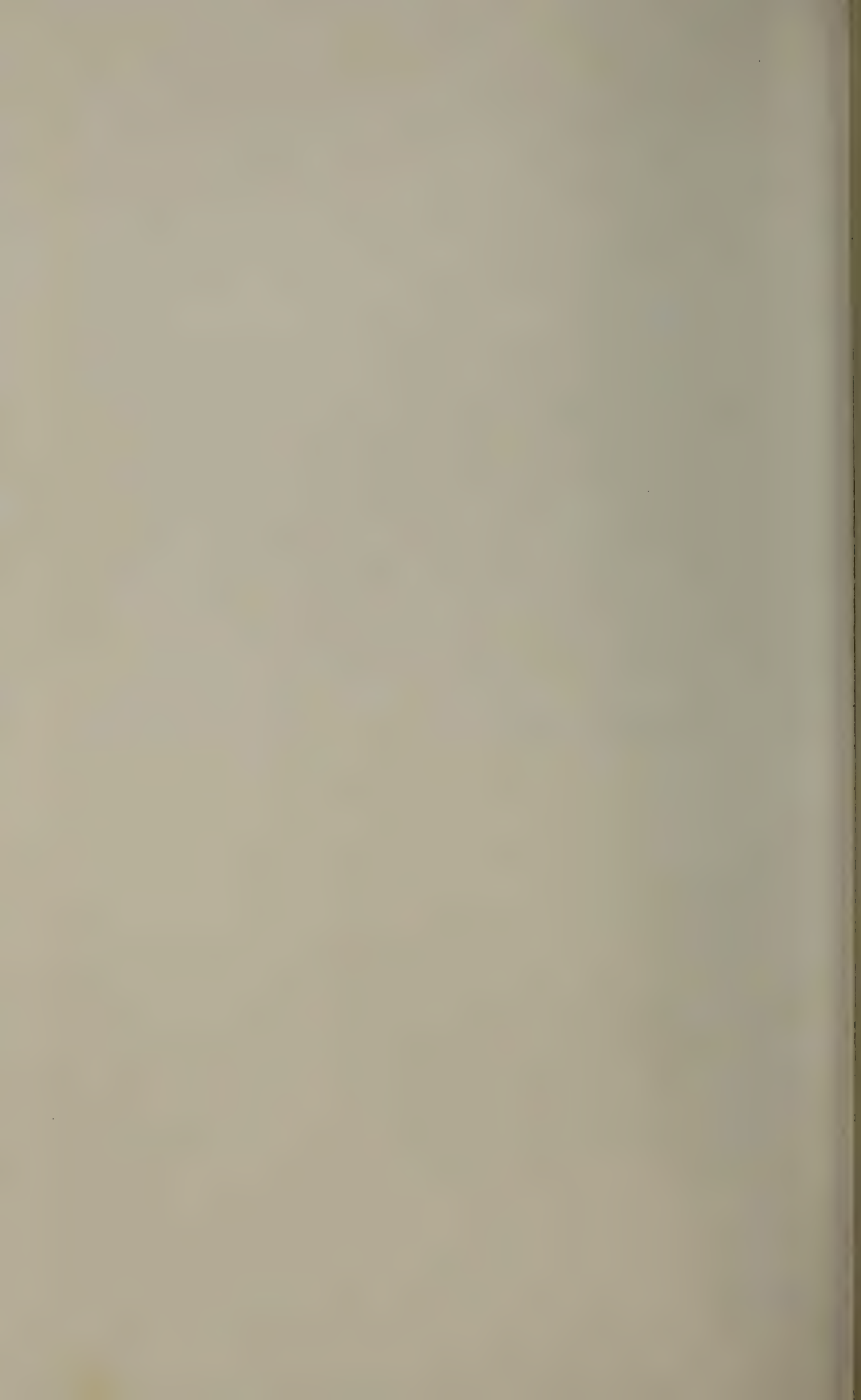
Fig. 9.

the field of the motor, but intermediately by means of a free independent primary machine regulated from the bridge standard. Its operation has proved reliable and the *Variag* and *Retvizan* have had excellent results with it, and several other Russian vessels are fitted with it. (See Naval Constructor Laurenti's article.)

Siemens & Halske, of Berlin, have invented a single motor electric steering apparatus which has fulfilled the tests so far exacted of it. A novel feature is that the motor itself acts as a brake to annul the great kinetic energy that usually renders stopping so difficult. With this motor is used a new type of steering standard, which is shown in the accompanying photographs (figs. 11 and 12). The commutator switch is in the upper part of the standard. When contact is made on the right side current is admitted to this to turn it to the left, and vice versa when turned to the right, thus moving the eccentric lever. The contact lever carries a pointer that can be placed on the scale to the position desired for the rudder. The rudder position indicator has a pointer which synchronically assumes the position in which the rudder



SIEMENS AND HALSKE ELECTRIC STEERING STANDARD.



is moved. This is done by means of a motor in the standard that sends the impulse to the distant commutator, which is connected to the tiller by means of a series of partial rings insulated on a tumbler thereon. When the two pointers stand directly in line opposite each other, the contact is broken, the steering motor is cut out and returns to the neutral middle position, the steering motor stops and the "distant commutator" remains in that position, while the movement of the rudder ceases. In the bottom of the standard is a gong which rings whenever the rudder passes the midship point. This serves to check the correctness of the indicator. If the indicator does not stand at zero when the gong sounds it may be moved by hand to zero, as there is simply a friction connection with the steering motor connections.

Advantage is claimed for the external pointer for an indicator in that the helmsman can, steering with one hand and holding the fingers of the other upon the pointer, keep his eyes upon the compass or upon the officer conning, and yet know the exact position of the helm. This would not be possible with the usual hand and illuminated dial type.

The following notes on the operation of the electric apparatus of the German coast-defense ship *Aegir* will supplement those on page 250 of No. XIX of these Notes, and will serve to show the difficulties experienced with these installations.

[From Marine Rundschau, October, 1901, p. 1041.]

1. THE STEERING GEAR.

The motors have not failed once, but had to be stopped twice owing to faulty service while in operation. In cleaning the carbon brushes pieces of carbon were allowed to fall between the brushes and the commutator, which, of course, resulted in considerable sparking. With greater care these interruptions in the operations of the dynamo could have been obviated. The rudder governors have not proved practical and have given rise to injuries in several instances, owing to the support of the contact roller breaking or jamming. Moreover, it was subsequently discovered that the rollers and contact surfaces were so badly burned and soiled from sparking, after only two or three days' use, that they ceased to be good conductors of the current, so that the rudder no longer followed the movements.

Owing to the jamming or breaking of the governors, the tiller, on three occasions, ran too far to the side, which resulted in the breaking of the wheel rope. The reason why this could happen in spite of the automatic cut-out was that the speed of the two motors, which ran in opposite directions, is not entirely alike. When the lever of the governor was laid amidships or the automatic cut-out put out of the circuit, one of the motors was usually a little behind; this was not noticed while they were running, but when the governor failed or broke this retarding resulted in the breaking of the wheel rope. This danger, while subsequently lessened by putting in a regulator, has not been entirely removed.

The frequent errors occurring during the first year in the indicator of the rudder positions were due mainly to the faulty laying of the cable, especially at the turning places. Since the cables were branched off to the different stations from a switch-board in the steering room the indicators have failed very seldom. Faults may occur in the instrument itself by reason of the breaking of the fine winding of

the electromagnets, owing to vibrations, after they have been in use for some time. Failure may also be due to imperfect contact of the rollers on the commutator of the step-by-step resistance.

To the defects enumerated must be added the circumstance that when first started the movements of the rudder are effected more slowly than in the case of steam steering gear; afterwards it runs faster.

Although the electrically operated steering gear on board the *Ægir* does not fully satisfy all the requirements, I am nevertheless of opinion that it is in many respects to be preferred to steam steering gear.

2. THE BOAT-HOISTING WINCHES.

The boat-hoisting winches, during the two years and a half while in operation, failed twice; the first time as the result of the breaking of the sliding contact which puts the shunt resistance in and out of the circuit. The defect was discovered at once and repaired in two hours' time. Since inspections at stated intervals have been ordered, such defects resulting from negligence have not occurred.

The second failure was due to faulty workmanship in the apparatus, which had passed unnoticed. The motors, having drum armatures with fashioned rods, have at both sides long projecting arms, which, for greater safety, are connected to a ring secured on the shaft. This ring had worked loose, as a result of the vibrations due to the running of the dynamo, and the arms, together with the ring, were thrown by centrifugal force toward the armature core. This injured the insulation of the field coils, and resulted in strong sparking.

These boat-hoisting winches are the most perfect auxiliaries imaginable, and I should be very glad to find them on board every ship on which I may have the honor to embark.

3. GUN-TRAINING GEAR.

The steam turbines and dynamos have always worked well, but frequent failures have occurred at the motors, especially during the first year, when the cable conductor was not well laid.

In one instance an injury occurred by reason of the fact that the gun captain did not put the starting lever quickly enough in stop position, thus losing control of the carriage. In order to repair the damage the carriage connections and shaft had to be dismantled.

Faults which could be easily remedied were due to imperfect contact of the carbons of the reversing gear. By not burning evenly, they opposed at times too much resistance to the passage of the current.

Faults not so easily remedied were those occurring in the regulating resistance which, when put into the circuit, makes the dynamo a compound engine. This resistance is too much covered, as the result of which the sliding contact failed in several instances.

If the reversing gear is improved—that is to say, if better contact, free from sparking, is secured—and the regulating resistance, whose sliding contact is actuated by the shaft of the reversing gear, is put in so that it can be better observed, I consider the gun-training gear an absolutely reliable auxiliary.

4. AMMUNITION HOISTS.

The machinery for this purpose has in itself worked as faultlessly as the boat winches. Faults which have occurred were due merely to the fact that the disconnecting gear is built too light. This unstable gear, constructed of gas piping, has not always responded promptly, thus causing the motors to stop too early or too late. I consider the ammunition hoists recently introduced preferable, as the motors can be kept running constantly.

5. STERN CAPSTAN.

This appliance has proved a great boon for the crew, and has been used for many purposes, such as rigging in and out of boats, coaling, etc. The armature burned out several times because the motor was overloaded. A double motor has recently been put in, which obviates the danger of overloading.

6. VENTILATOR FANS.

After a long time of service, the same defects were noticed here as in the dynamos—breaking of the armature covering, owing to friction at the lower pole piece when the bearings were too much worn, short circuits at the armature, and other minor faults. But with reasonably skilled personnel, defects of this kind can be easily removed either by repairing or by exchanging the armatures.

As to the value of electric auxiliaries generally, I am of the opinion that it lightens the service in every respect and considerably enhances the fighting efficiency and readiness of ships.

Such is the opinion of an expert based on thirty months' experience with electric auxiliaries in operation.

[Translated from *Rivista Marittima*, December, 1901, p. 536.]

TRANSMISSION OF ELECTRIC ENERGY ON BOARD OF WAR SHIPS.

By Naval Constructor C. LAURENTI.

From the first alternating-current dynamo, which made its appearance in 1876 on board the English cruiser *Minotaur* for the operation of a search light, to the electric installations of 800 horsepower which have been designed for the new United States ships of the *Virginia* type, is traced the progress which the use of electricity has made on board of war ships. The conservatism which is so characteristic of the older navies, the indifference with which all innovations are received, the time which elapses between the planning of a large ship and the moment when it is placed in commission (on an average five years), all these are obstacles which have interfered with the expansion of the use of electricity. At first it was applied to search lights, then to lighting purposes generally, then to ventilators, and only more recently to ammunition hoists, turret-turning gear, winches for hoisting ashes and fuel, boat winches, capstans, turbines for ejecting large masses of water, steering engine, to the operation of water-tight doors, to pumps for compressing air and water, refrigerating machines, machine tools, heating of small spaces, etc.

To the United States and Russian navies belongs the glory of having developed most extensively the use of electricity on board of their ships. In the other navies we find even now only some of the applications above enumerated, which, however, does not detract from the real progress actually attained by that branch of marine engineering. The tendency is mainly to supersede steam auxiliaries which are at some distance from the boilers by electric auxiliaries, and in some

cases, even for the operation of ventilators; for instance, electricity has already taken the place of steam in the very boiler and main engine rooms. Such substitution is rendered advisable by two reasons, one in the interest of economy, the other in the interest of warfare. There has been much discussion as to both, which, however, has not always been fair. But by this time the data furnished by experience has led to positive results, and it is of such data only that we shall avail ourselves in our arguments.

The question of the economic advantage of a large electric installation for the transmission of power on board of war ships over a steam plant has been much discussed in the United States Navy. Among the first to point out the advantages of electric installations were W. W. White ("Steam consumption of the main and auxiliary machinery of the U. S. S. *Minneapolis*," *Journal of American Society of Naval Engineers*, February, 1898) and S. Dana Greene, electrical engineer (Lecture delivered before the American Institute of Electrical Engineers, at the meeting of 1899). These were opposed by Lieutenant Robinson, United States Navy ("Auxiliary machinery for war ships," *Engineering Magazine*, October and November, 1899), and G. W. Melville, Chief of the Bureau of Steam Engineering of the United States Navy ("Electrically driven auxiliaries," *Annual Report of the Secretary of the Navy for the year 1899*, p. 708). But time appears to have adjusted the differences. To-day the magnitude which that Navy has given to the electric installations of the *Kentucky* and *Kearsarge*, and the still greater proportions of the installations designed for the battleships and cruisers to be built, show the strides which the new ideas have made.

The question, which has gradually been assuming importance, necessarily awakened interest in the other navies, especially the English. In England the question was discussed very thoroughly, first by G. R. Dunnell ("Marine engineering," *Brassey's Naval Annual*, 1899 and 1900), and subsequently by C. F. Grove ("The electrical equipment of ships of war," paper read before the Institution of Electrical Engineers of London, April 5, 1900. See the *Electrician* of April 27, 1900.) Between the divergent views of Greene and Grove on one side, and of Melville on the other, the best road, as ever, is the middle road, which has been cleared of obstacles and lighted by experience and by the power of figures, which have certainly more weight than any argument could have.

We will say at once that as far as we are concerned we leave out of the discussion the question as to whether the numerous auxiliaries located in the main engine and boiler rooms of a ship, as a rule mostly pumps, for which the alternate motion of the pistons can be made directly available, should be actuated by electricity or by steam, the latter being evidently the more convenient way, and we will confine

our arguments solely to machinery located outside of these compartments.

Let us see, first of all, the steam consumption to be charged to auxiliaries. Mr. White found, in his experiments on board the *Minneapolis*, that for the operation of the auxiliaries it was necessary to generate in the main boilers a maximum of 318.68 and a minimum of 55.06 pounds of steam per I. H. P., it being understood, of course, that the minimum consumption was by the largest machines nearest the boilers, and the maximum by the smaller ones more remote from the boilers. The general mean consumption—that is to say, including the apparatus in the engine and boiler rooms—was found to be 119 pounds of steam. Hence the consumption alone of the auxiliaries outside of the principal engine and boiler rooms must certainly have been, in case of that ship, superior to this figure. It is true that Mr. Grove, in experiments made with a group of auxiliaries on board the Japanese battleship *Shikishima* with an aggregate power of 65 I. H. P., found that these auxiliaries required per I. H. P. little more than 8 pounds of coal, burned in Belleville boilers equipped with economizers, the combustion being such as to evaporate from 9 to 10 pounds of water per pound of coal burned; that is to say, the steam consumption was about 36 kilograms (79 pounds) per I. H. P. But it should be noted that all the machinery of this ship was new and of the latest type, the piping well protected, hence the whole in the best conditions of efficiency.

But in this figure of Grove's no account has been taken of the influence, pointed out by Durston and which the latter had ascertained from some experiments carried out on board the English cruiser *Diadem* ("Recent trials of the cruiser *Diadem*," Transactions of the Institution of Naval Architects, 1898), of the distance of the auxiliaries from the boilers in operation, which experiments showed that the steam consumption of auxiliaries increased from 20 to 30 per cent when fed by boilers further remote from them. Taking this into account and referring to machinery already in use and not new, we may assume as a minimum average the figure of 50 kilograms (110 pounds) per I. H. P. for ordinary auxiliaries located outside of engine and boiler rooms.

The dynamo steam motors, in a rational electric installation, must be located very near the boiler rooms, sometimes also contiguous to the main engine rooms. These motors represent, as a rule, the more powerful of the ship's auxiliaries. They are of the double-expansion type and equipped with automatic governors for the admission of steam, hence very economical. For these Robinson admits per I. H. P. a consumption of 26 pounds of steam generated by the boilers. Allen states (Discussion of Durston's paper above referred to) that for the auxiliaries of the British cruiser *Amphitrite* the consumption was ascertained to be about 27 pounds per electric horsepower, or 22 pounds per I. H. P.; and 22.67 pounds of dry steam per I. H. P. was

found by experiments to be the consumption of the motors of the dynamo on board the *Kentucky* ("Tests of the electric plants of the battleships *Kearsarge* and *Kentucky*;"^a by Naval Constructor J. J. Woodward. Paper read November 15, 1900, before the Society of Naval Architects and Marine Engineers); hence the 26 pounds per I. H. P., as given by Robinson, may be taken as a maximum mean consumption.

A good modern dynamo motor of adequate power has an efficiency of 90 per cent. The same efficiency at least may be assigned to a good dynamo,^b and, granting that the wiring gives an efficiency of 95 per cent and the electric motors a mean of 80 per cent under the different conditions of operation, the work actually gathered at the shafts of the latter will be 61.5 per cent of that indicated by the motor. In other words, for each effective horsepower developed by the electromotors the boilers must generate on an average 19.5 kilograms (43 pounds) of steam.

In the case of steam-driven auxiliaries, assuming a mean coefficient of 70 per cent efficiency, which is sufficiently high, especially for small one-cylinder engines, there would have to be evaporated in the boiler for each effective horsepower produced 71 kilograms (156 pounds) of steam. With transmission by electricity there would therefore be attained a greater efficiency of 72 per cent.

It will at once be seen that this result means a great saving of fuel in the case of a large ship during a long run at an economic speed of 12 knots in time of peace. Let us assume that one-half of the power of all the auxiliaries in operation is absorbed by those which should preferably be continued to be operated by steam, and the other half by those which are to be driven electrically, such, for instance, as all ventilators (including those for the ventilation of the main engine and boiler rooms), ash hoists, workshop motor, refrigerating machine, water-closet pump, electric lighting, etc. For a large ship of about 13,000 tons displacement and 13,500 I. H. P. of the main engines, about 3,500 I. H. P. (one-fourth) would be required to attain a speed of 12 knots, which is economic speed, and if equipped with Belleville boilers with economizers, granting that, in order to supply steam for all apparatus, 1 kilogram (2.20 pounds) of coal is burned per I. H. P.,^c the

^aIn these same experiments it was found that, even at half load, these motors did not consume more than 25.67 pounds of steam per I. H. P.

^bIn the experiments referred to in the preceding note it was found that set No. 7 of the *Kentucky* gave a combined efficiency of motor and dynamo, with full load, of 82.2 per cent, which was the average of 25 experiments.

^cThis figure is rather low, but has been taken purposely in order to assume the most unfavorable case. It is, moreover, the figure attained on board the first-class ship *Goliath* of the English navy (to which all the data of the example chosen refer) during the long trial trip which she made between Plymouth and Colombo. (See "Memorandum respecting water-tube boilers in Her Majesty's ships, presented to both houses of Parliament by command of Her Majesty," London, 1900.)

coal consumption will be 81.6 tons a day. At the speed under consideration it may be assumed that the consumption of steam required by the auxiliaries will be at least 20 per cent^a of the total steam generated by the boilers, and hence a consumption, on the part of these auxiliaries, of 16.3 tons of coal a day in case all of them were steam-driven, while, in case of electric drive, on the basis above referred to, there would be a saving of at least 7 tons of coal a day. In a cruise in time of war, where it would often be necessary to operate other auxiliaries, such as ammunition hoists, turret-turning gear, air-compressing pumps, etc., the saving would be still greater; and there would be a further saving in the services required when at anchor, where the auxiliaries to be operated are usually those most remote from the boilers, as, for instance, boat winches, capstans, workshop motors, water-closet pumps, etc. .

The argument of economy of a large electric installation for the transmission of power is thus fully justified. Nor will we discuss the advantage of such an installation as regards reliability of operation. In spite of the preference which some navies still have for hydraulic installations, especially for the operation of large guns, this mode of transmitting energy is also gradually yielding to electric apparatus as the latter become more perfect and more practicable, which is evidenced by their more and more extensive use, for this particular purpose also, on board of the most modern ships.

It will not be out of place to refer also to the question of weight and space, and, in order not to make hypothetical computations, we will take an actual case for an example, namely, that of the electric plants of the United States battleships of the *Kearsarge* type, of which even the most minute details are fortunately known.^b As to size, these ships (12,375 tons) differ little from the example previously referred to. They have on board electric installations whose motors are capable of developing a maximum of 850 effective horsepower; and the weight of the same, including the resistances, switchboards, wiring, etc., amounts to about 71 tons. The generating sets are capable of developing 350 kilowatts of electric energy, and the total weight of steam engines, dynamos, switchboards, measuring instruments, steam piping, and valves, in the dynamo room, is about 82 tons. Assuming that four-fifths of this installation are required for the transmission of power, we have a total of 137 tons.

^aThis figure is the result of the experiments of the English cruisers *Diana* and *Hermes* (see the above-cited Memorandum) and of the experiments of the *Argonaut* (see "Trials and experiments made in H. M. S. *Argonaut*," by Sir J. Durston, Transactions of Naval Architects, 1899).

^bSee the two papers by Naval Constructor J. J. Woodward, the second one of which has already been mentioned, and the first, entitled "Electrical installations on battleships," was read before the Society of Naval Architects and Marine Engineers at the meeting held in November, 1899.

For auxiliary steam motors we may assume a mean weight of 60 kilograms (132 pounds) per effective horsepower; hence the 850 horsepower first mentioned would weigh 51 tons. Let us remember that the figure is below the actual weight when we compute at 30 tons the weight of all the steam and exhaust piping required for the service of this machinery, the weight of the stop valves, of the water in the pipes of the hydraulic plant which would be required for the operation of the turrets, the weight of the full water tanks for such plant, and the weight of the water collecting especially in the steam-exhaust pipes. We have thus a total of 81 tons, which is less, it is true, than the 137 tons of the electric plant. But it seems to us that the difference is more than compensated by the saving in coal. In the case first analyzed the ship, with a maximum coal supply of 2,300 tons, at an economic speed of 12 knots, would have a radius of action of twenty-eight days; so that if part of the auxiliaries were driven electrically there would be a saving, on the above basis, of at least 196 tons of coal, which could have been saved from the beginning without impairing the autonomy of the ship.

Those who express doubts as to the expediency of the use of electricity on board ship, frequently without having thoroughly examined into the question of economy and weight and assigned to these factors their proper value, also advance the question of space, stating the problem about in these terms:^a The space required by electric motors is about the same as that required for steam auxiliaries. The space required for electric connections is less than that necessary for steam piping. But the space occupied by the generating station or stations for the transmission of power is much greater than that which would be required if the use of electricity were limited to the operation of searchlights and some of the ventilators and general lighting, and such space is thus used to the detriment of the coal supply. This is not correct, and it is easy to see that the space required for electric installations outside of the dynamo room is, as a matter of fact, less than that necessary for steam-driven auxiliaries performing the same services.

For the maneuvering of the heavy gun turrets, the electric installation requires only a limited space under the turrets themselves, the same space that would be occupied by the hydraulic machinery, while the latter requires in addition space for the steam pumps for compressing air and for the feed-water tanks, which spaces are frequently subtracted from the coal bunkers, and owing to their high temperature they must moreover be well ventilated^b. Some ships have hydraulic apparatus, in addition to the steam apparatus, for steering

^a See Melville's paper above cited: "Electrically driven auxiliaries."

^b On board of large British ships having hydraulically operated barbette turrets there is for each barbette a steam pump of 250 I. H. P. for the hydraulic plant.

purposes, others have large boat cranes actuated hydraulically. For each of these services there is a steam pump in the vicinity of the engines and boilers for compressing the water, and these pumps, with their respective water tanks, frequently take from the coal bunkers spaces that are by no means negligible. These hints are sufficient to show that a comparison of the total space required for steam and electric plants, respectively, is perhaps to the advantage of the latter.

In order to save space, the different sets of apparatus of the generating station may also be arranged in two tiers, under the protective deck, as is the case on board the ships of the *Kearsarge* type, thus assembling in a small space a powerful center of energy.

Another advantage, of purely mechanical character, is that in all cases where great power is required for starting certain apparatus, such as winches, capstans, turrets, steering engines, ventilators, etc., the electric motors are better adapted than steam motors, because with the former a turning moment two or three times greater than the normal can be obtained, which is not possible with the latter motors; moreover, the former being rotating motors, they have a maximum effect when used toward putting in rotation bodies possessing inertia, such as ventilators, large turbine pumps, gun turrets, etc.

In addition to the economic and mechanical advantages, electric drive on board ship has an actual military advantage.

The drawbacks of transmission of power by steam on board ship may be summed up as follows:

1. Even admitting that all the auxiliary steam piping can be laid below the protective deck, and admitting further that all the motors above this deck are located in spaces protected by armor, there still remains the possibility of a shell exploding in a redoubt after piercing its armor, or of shattering the structure of the protective deck, though not perforating it. In either event, there is a possibility that the steam piping, being rigid, will be injured and that the escape of steam will render some spaces inaccessible, produce excessive noises, and may have fatal results for the personnel.

2. The injuries can frequently not be repaired with the resources on board and may temporarily disable the ship.

3. The steam piping, extending frequently from the extreme bow to the extreme stern, in order to serve the air-compressing pumps for the torpedoes and the steering machine, heats the spaces through which it passes, and sometimes the ammunition rooms, to such an extent as to cause deterioration of the explosives, which are becoming more and more delicate, and to render it almost impossible for the personnel to remain in the spaces containing the machinery, besides being a cause of additional and as it were constant consumption of energy in ventilating and cooling such spaces.

4. Steam motors to be put in operation require certain preparations which take time, so that they are not available at any moment.

For the transmission of energy by electricity, on the other hand, the following advantages may be enumerated:

1. The wiring forms a sufficiently flexible system to sustain slight displacements without being disabled, and even if a circuit should be broken only the motors which it feeds would be put out of action, without injuring the personnel or causing obnoxious noises; and in view of the resources at present available, and skilled personnel, it would be easy to trace the injury and repair it within a short time with the simplest of means available on board.

2. With the use of electric motors the excessive heat would disappear, thus serving a high humanitarian end in the interest of the health and well-being of the personnel in charge of them; moreover, it would result in a further saving by reducing the power of the apparatus designed for the ventilation of the spaces.

3. Electric motors need no period of preparations for being put in operation.

One requirement mentioned by us, which, if not essential, is yet highly important for attaining a maximum of economy and military efficiency of a large electric installation for the transmission of energy, is the existence of one or two large centers for the generation of energy in the immediate vicinity of the main engine and boiler rooms. It might happen, however, that the exigences of war rendered it necessary to have more than one generating center distant from these spaces.

In our opinion economy and military efficiency can be attained, even in this event, by a novel solution which has as yet not been tried on board of ships, namely, by actuating the dynamos of such generating centers by means of petroleum motors. Now that automobilism has made motors of this class more perfect and common, we see them invade industry and navigation more every day. Besides numerous craft now propelled by such motors we have already instances of submarine boats with petroleum motors of up to 160 effective horsepower (United States and English submarines). The holy terror which inflammable substances, including petroleum, have hitherto inspired on board ship will gradually vanish, as has vanished the terror of high pressures in boilers and high potentials of electric currents, when it is remembered that the petroleum can be kept in tanks alongside the dynamo rooms, with outboard communications for filling them, in cool spaces, since they would be far distant from the steam engines and boilers, and that the progress of such motors, especially those of high power, tends to the use of more and more heavy oils, which for that reason are less inflammable.

The advantages of petroleum motors for this purpose may be summed up as follows:

1. Lighter weight, since motors can now be had of over 100 horsepower, weighing not over 10 kilograms (22 pounds) per effective horsepower.

2. Prompter operation, since the motors can be made ready for operation inside of a few minutes.

3. Better inhabitability of the dynamo rooms, since there is no increased heat, provided good water circulation, either forced or induced by thermosyphon, is insured around the cylinders of the motors.

4. Comparative economy of operation, the consumption of these motors varying between 350 and 400 grams of ordinary petroleum per effective horsepower produced,^a and eliminating the periods of lighting and urging the fires required in steam plants.

5. Great speed of rotation of the motors, which admits of connecting them directly to the dynamo.

On shore electric installations with petroleum motors are already quite common, and, owing to the incontestable advantages which they offer, they will soon make their way on board of ships also.

Let us now cast a glance at the development which the electric transmission of power has attained on the warships of the different navies.

Electricity, as previously stated, was first introduced on board of warships for the service of searchlights. It was subsequently adopted for partial lighting and then for the entire lighting of ships, and later for the transmission of power by motors. Alternating current, which was at first introduced, was soon abandoned, and superseded by continuous current of low potential. Recently experiments have also been made with polyphase currents.

The generally adopted system of distribution is the two-wire system, with the main circuits in the shape of loops, under the protective deck, from which the shunts branch off. The light circuits are separate from the power circuits, to which, however, the searchlights are sometimes connected. The number of circuits varies. From a minimum of 2 main circuits, one for lighting and one for power, and a separate circuit for the signal lanterns, as adopted by the Italian navy, it rises to a maximum of 18 circuits, as found on board of the Japanese battleship *Shikishima*, 6 of which are for lighting, 4 for searchlights, and 8 for the electromotors.

The question of potential, much discussed in all navies, is yet far from having been definitely settled. After abandoning the original potentials, which were rather low, the English and United States

^aThe present high price of petroleum in Italy is due mainly to the high duty. It should be noted, also, that with this kind of motors the consumption is obviated which occurs in steam motors for lighting and putting out the boiler fires and for urging them.

navies have stopped at present at 80 volts, which appears to be a suitable compromise between the potential required for searchlights and that which renders good efficiency for the light plant. But the Americans do not seem satisfied with it. On the *Kentucky* and *Kearsarge* they are trying a three-wire system in order to obtain voltages of both 80 and 160 volts, with the latter of which the majority of the motors are fed at full speed, with the advantage that, when fed by 80-volt circuits, they attain about one-half the full speed. The three-wire system, however, entails considerable weight of the wiring and greater complication. Nevertheless, it would be interesting to learn, some time hence, the results attained on these ships. The French navy, also, has passed from 70 to 80 and 85 volts, but does not appear to have exceeded the latter voltage, while the Italian navy has passed from 65 to 110 volts, which voltage has also been adopted for the installations on board of German warships. But Russia adopted this voltage before either Italy or Germany did. On board some of the ships of the Austrian navy (coast-defense armor clads *Budapest*, *Wien*, and *Monarch*) a mixed system of distribution with continuous current and polyphase current is being tried. The compound dynamos have their armatures so arranged that at one end, at the brushes, continuous current is gathered, and at the other end, with collector rings, three-phase current.

The slow but steady growth of the voltage of electric plants will surely not stop where it is now. As these plants gain in importance the weight and cost of wiring at low potential becomes more and more onerous, while the weight of dynamos and motors remains very great. Nowadays industry furnishes material whose insulation is well adapted to stand the wholly metallic atmosphere of a modern warship; the personnel for operating and preserving it is becoming more and more skilled, and if the three-wire system on board the American ships gives good results at a pressure of 160 volts there is nothing to prevent our going even beyond that figure, and as a proof that it is possible we will cite the fact that the Italian submarine boat *Delfino* has had in operation for the last five years an electric installation which at full power works at 500 volts and at half power at 250 volts. The results have been such that we need not regret for an instant having taken the bold initiative.

In view of the present state of perfection of electric material, it is our opinion that even now a pressure of 250 volts can be risked on board ship without hesitation, at a great saving in price and weight and a corresponding economy in operation. The searchlights would not be an obstacle, for they can be connected in series and suitable resistances put in the circuit when not operated simultaneously.

We now come to the ratio of the potential of electric plants to the displacement of the ship. The data for the different navies, as shown

in the following table, vary considerably. Omitting the case of the coast-defense armor clad *Ægir* of the German navy, where the production of electric energy as compared with the displacement assumes truly remarkable proportions, the reader will see that the Russian navy is the most interesting in this respect. It is followed, in descending order, by the United States Navy, the German, Italian, French, English, and Japanese. It is not easy to trace the causes which may have influenced the different navies in the greater or less development of electric energy on board ship, but the fact remains that the youngest navies, like the Russian, United States, and German, are the ones which in the matter of electric service on board ship have preceded all others, including the Japanese navy, which, though young—very young, even—is yet entirely modeled after the British navy.

Ship.	Displacement in tons.	Type of ship.	Number of dynamos.	Amperes per dynamo.	Volts.	Total energy of electric plant.	Ratio between energy in kilowatts and displacement.
<i>Russia.</i>						<i>Kilowatts.</i>	
Admiral Nakhimoff ...	8,500	Armored cruiser..	{ 2 4	{ 400 700	{ 110 110	{ 404	0.047
Tsarevitch	12,900	Batt	{ 4 2	{ 1,000 640	{ 120 110	{ 580	.045
<i>United States.</i>							
Kentucky type.....	11,700	do	7	625	80-160	350	.030
Virginia type.....	16,250	do	{ 2 8	{ 1,250 625	{ 80 80	{ 600	.037
New cruisers	14,000	Armored cruisers..	{ 3 4	{ 1,250 625	{ 80 80	{ 500	.035
<i>Germany.</i>							
Ægir type.....	3,754	{ Coast-defense armor clad.	{ 3 6	{ 400 275	{ 120 120	{ 342	.091
F. Bismarck type.....	10,650	Armored cruiser..	5	590	110	325	.032
<i>Italy.</i>							
Garibaldi type.....	7,350	do	4	300	110	132	.018
Margherita type.....	13,427	Battleship.....	4	910	110	400	.030
<i>France.</i>							
Montcalm type.....	9,516	Armored cruiser..	4	400	80	128	.013
Carnot type	11,986	Battleship.....	4	600	85	204	.017
<i>England.</i>							
Drake type	14,325	Armored cruiser..	4	600	80	192	.013
<i>Japan.</i>							
Shikishima	15,087	Battleship.....	3	600	80	144	.009

Grove, in his paper, compiles a table to show the different maximum powers, in electric horsepower, of the motors devoted to the different services, in case of extensive electric drive on board a ship of 15,000 tons. But his estimate is not complete, because the use of electricity may be of even greater extent. Thus, for instance, the operation of water-tight passage doors and bunker doors may be effected by means of electric motors,^a whose power may be of 4 electric horsepower for bunker doors and 2 for passage doors. So also may large centrifugal pumps for the ejection of large masses of water from bilges be actuated directly by electric motors.

On board the Russian cruiser *Admiral Nakhimoff* there are five such centrifugals with motors of 60 electric horsepower each.^b Furthermore, it is well known that heating by electricity has also been introduced on board ship. This mode of heating is especially adapted to smaller spaces, such as staterooms. We call attention to the installations of this kind already in operation on board of several trans-Atlantic steamers, with heaters absorbing about 550 watts each, or about two-thirds of an electric horsepower.

In our opinion, it would also be very expedient to extend the use of electricity more generally to anchor capstans. Two reasons should lead thereto: (1) That by the use of electric motors much greater power than otherwise can be obtained instantly; (2) that it would obviate the consumption of steam resulting from the great distance of the capstan motor from the boilers. The first anchor capstan with electric motor was set up on board the German coast-defense armor-clad *Aegir*, but has since been abandoned, while the British navy, although the most conservative of all with regard to this mode of service, placed such capstans on board the *Duncan*, *Irresistible*, and other similar ships, and appears to have definitely adopted them for all new ships.

Taking as a basis the example given by Grove, of electric drive on board a war ship of 15,000 tons, and adding thereto the uses not considered by him, namely, the operation of water-tight doors (10 passage and 16 bunker doors), the turbines for the ejection of large masses of water, the electric heaters for living spaces, the motor for the refrigerating machine and for the anchor capstan, and with better apportionment of the energy required for the different services, as compared

^a Electric operation of water-tight doors is found on the Italian battleship *St. Bon* and the U. S. cruiser *Atlanta* (see C. Laurenti, "Porte stagne a manovra elettrica" (electrically operated water-tight doors), *Rivista Marittima*, Jan., 1900).

^b A large centrifugal of this kind with electric motor has also been set up on board the Italian ship *Puglia*, and others have been designed for the ships of the *Regina Margherita* type.

with the plants on board of the United States ships,^a we should arrive at the following figures:

	Electric horsepower.
Ventilators for different spaces of the ship and for forced draft of the boilers.	250
Steering motor	200
Anchor capstan	50
Deck winches	170
Boat-hoisting winches	150
Winches for hoisting fuel and ashes	100
Workshop motor	5
Refrigerating machine	10
Motors for operating turrets, guns, and rammers	250
Ammunition hoists	150
Air-compressing pumps	10
Motors for water-tight doors	84
Turbines for ejecting large masses of water	300
Electric heating of living spaces	27
Total	^b 1,756

In order to compute the power to be assigned to the generating centers, for comparison with the maximum requirement of the power plant, we must preface some observations. For operating the turrets of the *Kearsarge*, with two 13-inch guns each, although there are in each of them two motors of 50 electric horsepower, the tests have shown that the maximum consumption was 40 horsepower, with either

^a The plants on board the U. S. battleships *Kentucky* and *Kearsarge* are composed as follows:

Services performed by the motors.	Number of motors.	Maximum power of each motor.	Total electric horsepower.
		<i>Electric horsepower.</i>	
Turning of two armored turrets	4	50	200
Rammers of four 13-inch guns	4	5	20
Operation of four 13-inch guns	4	2½	16
Ammunition hoists:			
13-inch guns	4	20	80
8-inch guns	4	6	24
57-milimeter guns	2	6	12
Endless chains of main hoists	10	3¾	37.5
Air-compressing pumps	3	3	9
Ventilators for different spaces and for forced draft	14	12	168
Forward boat cranes	2	50	100
After boat cranes	2	20	40
Deck winches	6	25	150
Total	59		850.5

^b Mr. S. Dana Greene (previously cited) states that all the auxiliary motors of a modern first-class battleship, hence including those in the engine and boiler rooms, require 2,000 horsepower; thus he confirms our figures, taking into consideration the increased energy introduced by us for other services not usually performed by steam motors.

one or two motors in use.^a On board the Russian cruiser *Admiral Nakhimoff*, the electric motors of the turrets, with two 9-inch guns, require 15 electric horsepower with the ship in a horizontal position and 30 electric horsepower with the ship listing. Hence, in the case under consideration of a ship with two 13-inch turrets, we may assume that the maximum power required, as effective consumption, is 50 horsepower. We may further assume that the maximum power required for the ammunition hoists is four-fifths of that which would be necessary if all of them simultaneously were using maximum power. Let us suppose further that in the most unfavorable case, in battle, all the ventilators, ash-hoisting winches, and compressor pumps were in operation, and that the steering gear were operated at full power, the maximum energy required would be 800 electric horsepower at the motors, or, taking into account the mean efficiency of 95 per cent of the line, 620 kilowatts at the generating center. Granting that additional 50 kilowatts are required for lighting and at most 60 kilowatts for the search lights, the power of the generating center would have to be 730 kilowatts; that is to say, one and one-fourth times that estimated for the latest battleships of the United States Navy.

Into how many sets should this power be subdivided? Such subdivision is governed by the number of generating centers, which, of course, must be protected—that is, located below the protective deck or within the armored redoubt. The ships hitherto built have as a rule only one generating center; but the idea of two generating centers, one forward and one aft, is beginning to find favor and will be carried into effect, for instance, on the Italian ships of the *Regina Margherita* type, while it has already been consummated on board the French cruiser *D'Entrecasteaux* (8,114 tons) and on several ships of the Russian navy, namely, the *Bayan* (7,800 tons), the *Tsesarevich*, and the *Nakhimoff*, the latter having three such centers, two aft and one forward. Such subdivision is advisable only for reasons of a military character, as it diminishes the general economy of the installation.

As to the power of the different electric units or sets into which the power of each center should be subdivided, economy of weight, operation, and cost render it advisable to make it as great as possible. The most powerful sets at present in use are of 100 kilowatts, but experts counsel the adoption of sets of 150 and 200 kilowatts, preferably the latter, in conjunction with a few sets of 50 kilowatts in order to provide for the limited requirement of energy for services in port. It can not be denied that dynamos possess the advantage that for a certain length of time—an hour or two—they can be urged to yield, without any risk, one and one-half times their maximum normal capacity, and the respective steam engines should be proportionate to

^a See the paper previously referred to, "Tests of the electric plants," etc.

such exceptional capacity, in order that it may be available in case of emergency.

The continuous-current dynamos and motors used on board ship are of the ordinary commercial type and have no special features. The dynamos and large motors are 4-pole and sometimes 6-pole, as on the *Kearsarge* and *Kentucky*.

The steam engines, coupled to the dynamos, are of different types—single, compound or triple-expansion, vertical, of from 300 to 400 revolutions a minute, all with automatic expansion governors. Of late, for large installations, steam engines of 500 and more revolutions, with forced lubrication, have been introduced. Steam turbines, which were used at first, disappeared afterwards, but at present they are beginning to reappear as the result of recent important improvements. Their principal advantages are the small space they require, the absence of vibrations, and small weight.

The electric motors adopted on board ship have nearly all water-tight casings for protection from water and coal dust. Their water-tightness is tested by jets of water under pressure against the casing. The increase of temperature allowed in the operation of electric dynamos and motors varies in different navies. In the tests of the electric plants of the *Kearsarge* and *Kentucky* there was in a single set only the maximum increase of temperature in the armature, at full load, of 23.5° C., the temperature of the room being 35.5° C.; that is to say, the temperature of the armature was 59° C., while on board the French cruiser *D'Entrecasteaux* the temperature of one armature was 100° , the temperature of the room being 27° to 28° .^a While it is not advisable to allow an excessive increase of temperature of the dynamos so as not to compromise their existence, it is not well, on the other hand, to set the limit too low so as not to increase the weight too much. An increase of 20° to 30° , in either dynamo or motor, seems admissible.

At each generating center there is a switchboard with all the measuring and regulating apparatus, the resistances, circuit breakers, etc. By means of this switchboard the dynamos can all be placed in parallel. Near each motor is another small switchboard with the necessary circuit breakers and rheostats, and sometimes, when the control of several near motors can be united on one board, there may also be some measuring instruments. The two wires of one and the same circuit, especially of the more important ones, are always separate; the return of the current is never through the ship's hull. The lead-protected cables which have been in general use in electric installations on board ship are beginning to be abandoned. At present, outside of the usual insulating layer, they are protected by sheet-iron casings, with removable coverings, and where there is lack of space they run in iron tubes varnished on the inside with some insulating composition. Thus pro-

^aSee *Rivista Marittima*, November, 1899, p. 349.

tected they are carried through engine and boiler rooms, coal bunkers, ammunition rooms, etc. Proper provisions are made for carrying them through water-tight bulkheads.

Before leaving this argument, it may not be superfluous to speak of the system which has found such general favor for steering by means of electricity. The steam steering machines, which until recently have been used almost exclusively, are of all the auxiliary motors the least economic for this purpose, either because they do not work with expansion, or owing to their great distance from the boilers. Hence electric transmission of power for this purpose offers the greatest advantages.

The system adopted by the United States and Russian navies^a and also by many merchant vessels is that of the Electro-Dynamic Company of Philadelphia. It is not clearly understood why the manufacturing company prefers to have the motor or excitor dynamo at the generating center, while sending the current to the field of another large motor situated in the same compartment, which latter is employed for the large dynamo intended to furnish current to the steering motor. This greater complication might be obviated to the advantage of the weight and bulk of the plant. In any event, the fact that the system has been extensively adopted by the navies mentioned, for the smallest vessels to the largest battleships, indicates that it answers all the requirements of such apparatus.

Aside from the power and lighting circuits, all the other electric circuits on board are secondary circuits, located in any part of the ship, and generally fed by dry cells or accumulators. The most important ones among these circuits are those for the transmission of commands, which are being constantly perfected and are acquiring great importance on board of warships. The transmission of orders through voice tubes, as now in general use, loses its efficacy in battle by reason of the firing of guns and the noise of the many apparatus in motion. In this case, also, electricity is acquiring indirectly high military importance, for the reason that it eliminates certain drawbacks, that the wires are not so easily disabled as the voice tubes in case of local injuries, and that they can be more readily repaired. Nor should the advantage be overlooked that the same order can be transmitted simultaneously to several places, thus obviating the danger of orders receiving erroneous interpretation by repetition.

The functions which electricity will be called upon to discharge in the future on board ship can not be foreseen, but before long it will surely have superseded on all warships the steam-driven auxiliaries scattered through the different spaces.

^aThe following ships of the United States Navy are equipped with electric steering gear: Battleships, *Pennsylvania*, *Ohio*, and *Indiana*; cruisers, *Baltimore* and *Brooklyn*; besides 8 tenders. Of the Russian navy: Battleships, *Oslabya*, *Alexander III*, *Pobieda*, *Peresviet*, and *Retvisan*; cruisers, *Gromoboi*, *Pallada*, and *Variag*.

On shore it has been found expedient in the high-speed locomotives to actuate the shafts by means of electric motors fed by the current of a dynamo located in the locomotive itself. And would it not be possible that some day, especially with the introduction of the steam turbine, it would be found expedient to transform the main engine room of a ship into a great generating center of electric energy, which, radiating current to all the different parts where work is to be performed, would also be used for the motors intended for the propulsion of the ship?

Nowadays it is no longer safe to smile at anything which at first sight may seem impossible, and in this case it is truly to be hoped that it will be realized, considering that the great displacements toward which all navies are tending would render the increase of weight resulting therefrom less onerous. And how many other advantages, especially of a military character, would be gained! First among them the possibility of actuating directly from the bridge or conning tower the propellers of the ship.

In any event, it is certain that the great future of electricity on board of warships is becoming more and more assured.

V.

WIRELESS TELEGRAPHY.

By Lieutenant CHARLES L. POOR, United States Navy,
Staff Intelligence Officer.

The material progress of the year in wireless telegraphy may be said to be in the matter of length of transmission, in which wonderful advance has been made. Something has been done in syntony also, but unfortunately in far less degree, for this latter is of more importance for naval purposes than distance of transmission.

Before proceeding to a brief review of progress in this more important matter of syntony, it may be well to note briefly the remarkable feats in transmission accomplished by Marconi during the past year, though his wonderful results have been made generally familiar.

On December 11 and 12, 1901, using a receiving wire 400 feet in height, supported by a kite, Mr. Marconi claims to have received at Signal Hill Station, St. John, Newfoundland, signals transmitted from his exceptionally powerful station at Poldhu, Cornwall, England, distant from the point of reception about 1,800 miles. The signals, which were in the form of the repeated sounding of the letter "S," were very faintly noted in a microphone receiver. It is stated that Poldhu had attempted for some time to transmit "S" to Newfoundland before the signals were heard finally by Mr. Marconi. No further communication or any regular signals are stated to have been sent. Atmospheric "strays" might so easily account for the sounding of "S" in the very delicate receiver, and the distance transmitted was so unprecedented, that the scientific world was disposed to be very doubtful and incredulous as to the actual genuineness of this experiment. In a later series of tests, however, carried out on board the steamship *Philadelphia*, Mr. Marconi would seem to have substantiated his claim to great results, for the messages were taken on a recording instrument and corroborated by the officers of the vessel.

The *Philadelphia* sailed from Cherbourg on Saturday, February 1, at 6 p. m. Two hundred and fifty miles west of Poldhu the first

experimental message was received, which read, "Stiff southwest breeze. Fairly heavy swell." That same night, when the *Philadelphia* was 500 miles off Cornwall, a second message was received, reading, "All in order. Sign. Do you understand?" Both of these messages the chief officers of the ship signed. On the 4th, when the *Philadelphia* had passed the 1,000-mile mark of her voyage, the captain and first officer of the vessel received a message, "Fine here. Thanks for telegram." The following morning saw the receipt of a fourth message, when the *Philadelphia* was 1,163 miles west of Poldhu. It read, "May every blessing attend you and your party." The fifth message, which was the last that came in words, was received on the same day at a distance of 1,551 miles, and its import was somewhat similar to that of the second. After the receipt of the fifth message the letter "S" was telegraphed by the operator at Cornwall merely to inform those on board the vessel that the station was still at work. Finally, when the liner had passed the two thousand and ninety-ninth mile, the tests were stopped. The messages mentioned were only a few of those actually received. Communication was kept up almost constantly; but it was deemed unnecessary to submit to the public more than half a dozen signed tapes.

In connection with these experiments it is claimed that the *Umbria*, equipped also with Marconi apparatus and following the *Philadelphia* closely was unable to intercept the messages to her. This would appear to be a triumph for syntony, were it not for the fact that the *Umbria's* operator was hardly a disinterested person, and we have no assurance of sincere effort on his part to intercept the messages, or to emit confusing waves himself.

The claim would be more impressive and more convincing had the following vessel been equipped with a rival system or had her Marconi apparatus been operated by naval authorities. It is sincerely hoped that thorough and impartial tests will soon be undertaken to sift fully the various claims now being made as to immunity from interception or interference. The following notes on syntony from the very thorough lecture on wireless telegraphy by Captain Ferrié, of the French army telegraph service, cover the ground of progress to date:

SYNTONIZATION.

The equipments we have indicated in the foregoing utilize the phenomenon of multiple resonance; that is, the effect of electric hammer blows produced by the very deadened oscillations of the transmitter upon the resonator constituted by the receiving antenna.

Efforts have been made to improve the utilization of the energy by according the receiving antenna with the period of the oscillation made by the transmitting antenna. A first attempt was made by Marconi, who, without making any change in the transmitting arrangement, constructed for the reception a sort of special transformer whose primary was in series with the antenna and the earth, and whose secondary was interposed in the circuit of the coherer. The length and form of these series windings were, it seems, functions of the antennæ heights; that is, of the periods.

Whatever the exact rôle of this transformer, it is certain it enabled its inventor to better notably the distances of communication obtained where the coherer was directly connected to the antenna. As an offset it did not permit a clear sorting between the transmitted oscillations and different periods.

The periods obtained at the transmitter are not themselves very distinct, as we have seen above. An effort was then made to regularize this period and obtain a maximum of utilized energy by diminishing as much as possible the deadening of the oscillations of the antenna. Two schemes are at present in use, or rather are actually made public. Both are organized in such a manner that the antenna no longer plays a notable part in the formation of the oscillations. The latter are produced in closed circuit; that is, with very distinct periods and without perceptible deadening. The antenna only serves to transmit the vibratory movement to the ether.

The first of these arrangements employed by Marconi is arranged as follows (fig. 1):

The oscillations are produced in a closed circuit of the oscillator S of a capacity K and of the primary of an ansonval transformer N.

They have, therefore, a well-defined period, $T = 2 \pi \sqrt{LC}$, since L and C are equally defined. Those oscillations induce others in the secondary of the transformer, one extremity of which is connected to the earth and the other to the antenna. It should be remarked that from the moment that, in this case, stationary waves are still produced in the antenna, it becomes necessary, in order to obtain a maximum utilization of the energy, to have a maximum loop of electromotive force at the top of the antenna and a node at the earth; in other words, the circuits of the oscillator and the antenna must be accorded. This result is obtained in varying tentatively for a determined length of antenna the capacity K or the number of turns of the secondary of the transformer.

In order to syntonize the receiver on the period of the transmitted oscillations Marconi employs for the reception an arrangement analogous to that for transmission (fig. 2). The primary of a transformer (jigger) is interposed between the antenna and the earth, the secondary divided in two parts and connected by the outside extremities to the two posts of the coherer and by its two inside extremities to those the cell-relay circuit. Moreover, a condenser of small capacity, K, is shunted to the inside extremities and two resistance coils, f , are interposed on the relay-cell circuit. In order to obtain accordance of the receiver with the transmitter it is necessary to accord with the period of the transmitted oscillations: (1) The circuit of the antenna; (2) the coherer-condenser circuit. The first accordance is easily done by giving the receiving antenna a length equal to that of the transmitting antenna including the length of the circuits of the transformer, which are interposed and whose capacity and self-induction are negligible, given their small number of wire windings. Each one of the semisecondaries has a length sensibly equal to that of the antenna; that is, to one-fourth wave length, taking, however, into account the effect of the capacity and of the self-induction of the two semisecondaries, which leads to the shortening of their lengths. The primary of the transformer, being in immediate proximity to the earth, is situated at a node of electromotive force, but at a loop of intensity of the oscillations which are formed in the receiving antenna. The induction on the secondary will therefore be maximum. On the other hand, as the coherer presents when at rest a practically infinite resistance, the whole of the secondary-coherer circuit will be placed in the conditions of a Hertz resonator. There will be formed a loop of electromotive force at each extremity; but as each semisecondary represents one-fourth of the length of transmitter wave, the whole will represent a semilength of wave. We will therefore have a variation of maximum potential at the two posts of the coherer, and, hence, a maximum of actions.

M. Slaby employs a noticeably different arrangement: For transmission (fig. 3) the antenna is shunted to the circuit in which are formed the oscillations, and which

comprises the oscillator S, a capacity K, a self-induction F, and a coil B of large coils. In addition, this circuit includes one portion of the ground between two connections to earth, T and T'. The oscillations therefore are of well-determined period, but likely very deadened, owing to the interposition of a portion of ground in the circuit.

In order to obtain in the antenna a maximum effect, it is necessary to accord the period on the length or inversely. In this latter case a certain number of turns of the coil B must be added or subtracted.

It should be noticed that if the coil B presents a strong resistance and if the values of the capacity and of the self-induction F are selected so as to balance one another, we revert to the ordinary arrangement generally employed.

For reception, Slaby makes use of a very ingenious arrangement (fig. 4): The receiving antenna being connected directly to the earth, a shunt is taken to it in the vicinity of the ground, and this shunt is connected to the coherer, which in turn is connected to the earth by its other post by means of a condenser. Shunted to the armatures of this condenser is placed the circuit, comprising the battery and the relay. The object of the condenser K is to protect the oscillations from the resistance of the relay. The length of the shunt of the antenna to the coherer is so regulated that, being added to the height of the antenna, it gives a length equal to the semilength of the transmitted wave. We thus have a maximum effect in the resonator formed by the antenna and the shunt, and consequently a difference of maximum potential at the extremities; that is, at one post of the coherer, whose other post is maintained at zero potential. As a consequence, we will have a maximum of effect. The foregoing argument does not appear to be free from all criticism, for the connecting of the antenna to the earth seemingly results in maintaining a node of electromotive force at the shunting point, and the length l should have for value one-fourth of the wave length transmitted in order that there be a maximum loop at the coherer, and then the total of the resonator will no longer represent one-half length of the transmitted wave. Very likely it is in order to make the necessary correction that Slaby interposes between the shunt and the ground a coil with large turns (fig. 5). The shunting point will no longer be necessarily a node, and the argument will be applicable. Whatever it may be, Slaby replaces in most cases the straight shunting by an Oudin's resonator, whose effect, as is known, is to enlarge the variable electromotive force due to a divided effect of capacity and self-induction (fig. 5).

Both the Marconi and Slaby dispositions permit us, as is seen, to obtain a maximum utilization of energy stored by the receiving antenna, thanks to the syntonization realized; but it is evident that neither, in consequence of the phenomenon of multiple resonance, will prevent the receiver from receiving signals transmitted at a different period, provided they have sufficient energy. Nevertheless, the effect of those nonaccorded oscillations will be smaller than that of the syntonized oscillations, and reception will only take place at a shorter distance. This has been clearly demonstrated by practice. We see besides that it is possible, by means of the two methods, to regulate a receiver in such a manner as to allow it to receive oscillations of a certain period and not to receive oscillations of a very different period, provided that the transmission of the latter be not made with too great an energy and at too short a distance. Nevertheless, Marconi and Slaby have succeeded in regulating two receivers so as to permit them to receive simultaneously, by means of the same antenna, two different messages transmitted with two very different periods.

Marconi obtains this result by first regulating each receiver connected separately to the antenna, so that it registers the signals transmitted with one of the periods and not those transmitted with the other. This adjustment is made very easily, but should the two receivers be simultaneously connected to the antenna, there occurs a confusion of signals, due to the fact that after the registering of each signal the

coherer is very supersensitized and becomes capable of being actuated by oscillations of feeble energy, and especially by those for which the jigger is not syntonized. Besides, the circuit formed by the two shunts and the connections to the earth may present a phenomenon of individual resonance which will disturb the effect of the resonance of the two circuits—antenna-jigger-earth. In order to prevent these perturbations Marconi interposes on the connection (fig. 6) of the receiver of long waves a self-induction F , and on the receiver of short waves a small capacity K . The result of this disposition is to destroy the syntony of each of the circuits, antenna-jigger-earth for the two transmitted oscillations, preserving only the accordance of the resonators (condenser semisecondary, coherer semisecondary) of each of the receivers, for one or the other of the transmitted periods. But this destruction of the syntony is less complete for the long waves than for the short waves in the circuit antenna-self-jigger J -earth in consequence of the resistance of F , great with short waves than with long waves. It is the reverse for the effect of the little capacity K on the second circuit. But, in addition, the effect of the self-induction F and the capacity K is to reduce very decidedly the utilized energy, and, as a consequence, the possible distance of communication.

On the other hand, in practice it would be preferable to have as many antennæ as there are receivers. Slaby obtained a similar result, but at shorter distances, by shunting on the common antenna two Oudin resonators properly selected, each connected to a receiver (fig. 7). The selection of the Oudin resonators was made in such a manner that the posterior extremity of each of them was a loop of potential force for one or the other of the two transmitted oscillations. But, in virtue of the observation already made above, the effect obtained is very likely better when the shuntings are made at different points of the antenna instead of both being made at the base, in order not to have perforce a node of potential force at the junction point which would interfere with the establishment of the greatest resonances.

Syntony Blondel system. Blondel pointed out as far back as 1898 another process which consists in according together, not the frequencies of the individual electric oscillations of the transmitter and the receiver, but artificial frequencies much lower, quite arbitrary, and independent of the antennæ, viz, the frequency of the charges of the antenna and those of the vibrations of a selective receiver such as the monotelephone of Mr. Mercadier. It suffices to maintain the frequency of the interrupter very constant and equal to the individual frequency of the receiver.

One can also make use of a coherer or an autodecoherent anticoherer, combined with the telephone. Each group of waves of high frequency rapidly deadened, acts in a bunch, like one single concussion, on the telephone of slow vibration, the latter besides remains sensibly sinnsoidal, thanks to inertia. The mechanical elasticity can also be replaced or strengthened by an electric elasticity, by connecting to the waves detector in use, a capacity so arranged as to form a circuit in pseudo-resonance with the transmitting station.

This system lends itself to an easy differentiation of the signals in a receiving station, for acoustic syntony is more distinct, in a general way than electric syntony, but it necessitates the use of autodecoherent coherers, which are more sensitive and irregular and which now limit its use to shorter distances.

Summing up the status of wireless telegraphy to-day we may say that it is still imperfect, offers yet many obstacles to success, is complex, costly, and delicate, and continues to be uncertain in transmission. Nature continues to fight against it. Last summer, during his experiments between Antibes and Corsica, in the Mediterranean, Marconi was unable to communicate after 10 a. m., owing to atmospheric conditions, and there has been found also peculiar atmospheric inter-

ferences for some time after sunset and during electric storms. These parasitic influences are a serious menace.

In spite of all these disadvantages, wireless telegraphy offers so much in its present maritime field that it is being vigorously taken up everywhere. At present there are more than 220 men-of-war and merchant vessels with wireless installations, as well as numerous coast stations.

The five principal systems in use are those of Marconi (Italian), Rochefort (French), Ducretet-Popoff (French-Russian), Slaby-Arco (German), and Braun (German).

Numerous other inventors have effected modifications or improvements, but these are the systems most extensively adopted. The Marconi apparatus has been so thoroughly described in previous notes that further notice is not necessary. Appended will be found descriptions of some of the other systems.

Special progress during the year has been noted in the following countries:

Austria.—After a series of successful experiments between two castles, which were carried on for many weeks under the charge of army and naval officers, the Austrian Government has ordered the installation of the Rochefort system in its vessels for further trial at sea.

Denmark has installed the Slaby-Arco system at the light-ship *Wyl*, and the Blavanschuck light at Esbjerg, 19 miles distant, and also at the *Horns Riff* light-ship, distant 31 miles from the light-ship.

France has made thorough trial of the Ducretet-Popoff, Rochefort, and Tissot systems, the later being the modified Ducretet system devised by Captain Tissot, of the French navy. At present France is conducting in the Mediterranean a series of trials with these systems, and it will probably adopt, shortly, one of them exclusively.

The Rochefort system, which seems to have had much success of late in France and Austria, has for its chief point of difference the use of a uni-polar transformer and a magnet-regulated coherer. There is also a double tapper which taps the coherer both in its go and return motion. The coherer is regulated by varying its distance from the permanent magnet above mentioned.

Germany has gone thoroughly into the question of wireless telegraphy, and has some 50 vessels equipped, or to be equipped, with the Slaby-Arco system. Numerous tests have been made and a course of instruction in wireless telegraphy has been established on the torpedo depot ship at Kiel. The German military authorities also have been making trials with portable wireless telegraphy with balloon suspensions of the antenna. In July last a series of successful tests were made by the squadron under Prince Henry in communicating, during a short cruise, with the shore stations at Helgoland, Borkum, and the Elbe light-ship.

Fig 1.

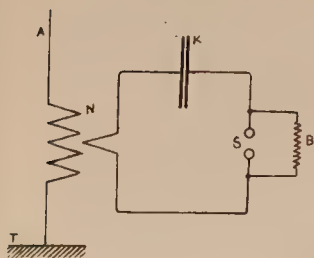


Fig 2.

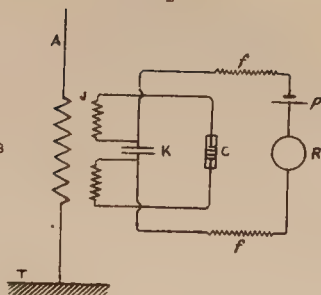


Fig 3.

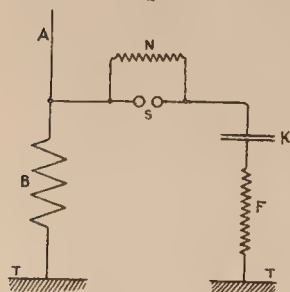


Fig 4.

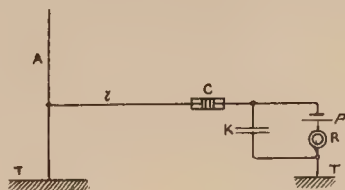


Fig 5.

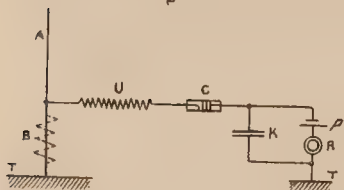


Fig 6.

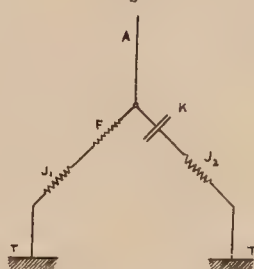
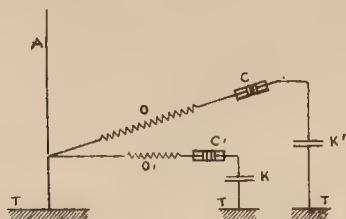
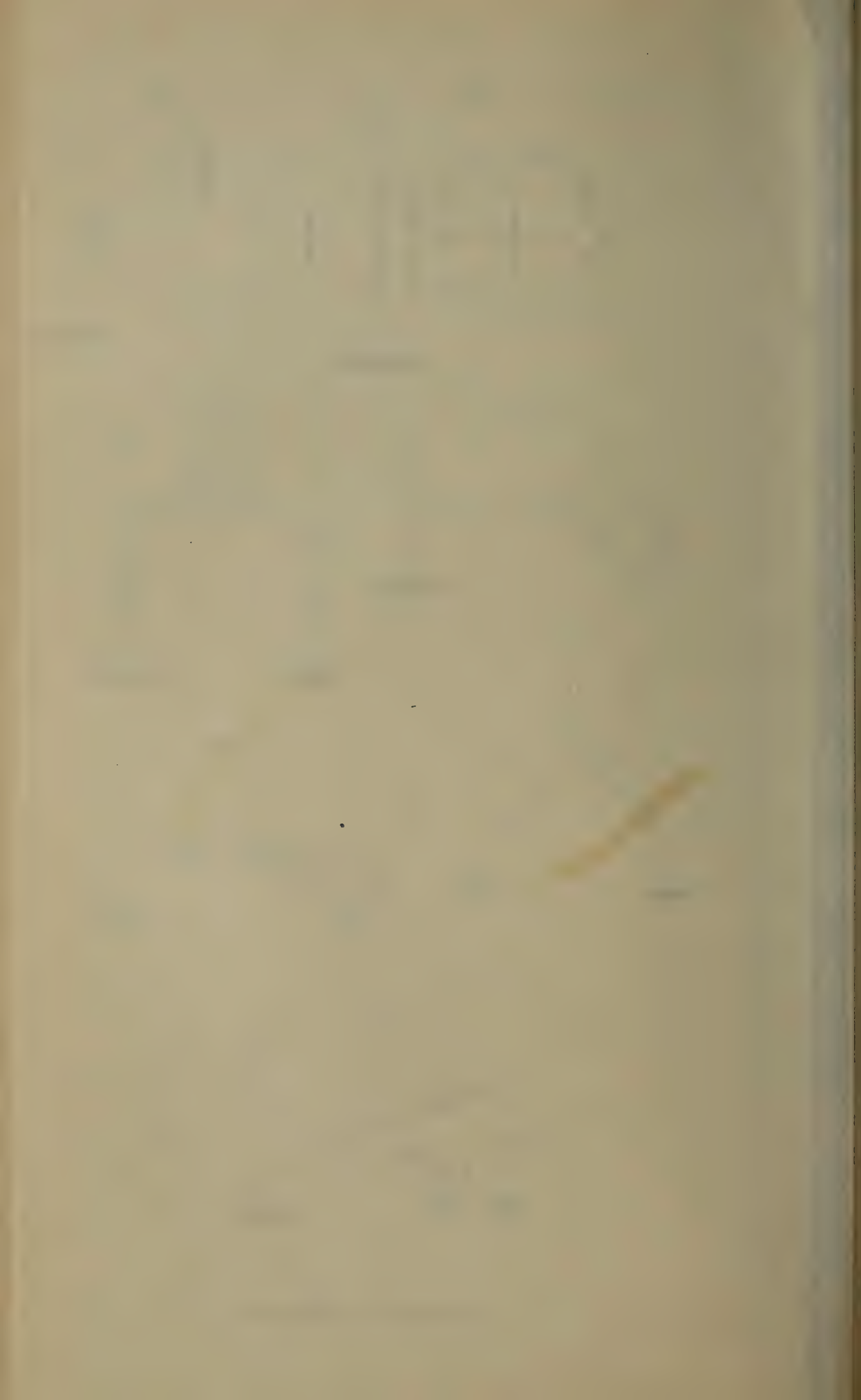


Fig 7.





In February last, in order to make trial of another German system of wireless telegraphy, the Braun, manufactured by Siemens & Halske, of Berlin, thorough comparative trials were carried out.

The harbor ship *Friedrich Carl*, equipped with apparatus for both systems of wireless telegraphy, put to sea in the direction of Korsör, steadily increasing her distance from the shore and exchanging messages alternately with the two stations established at the signal station Bülk. During the first few hours the exchange of telegrams with both systems was equally good and accurate. When the distance had been increased to about 90 kilometers (56 miles) the connection with the Braun station gradually failed. At a distance of 130 kilometers (81 miles) the Slaby-Arco apparatus also became silent. While it must be admitted that the electric range and constructive perfection of the Slaby-Arco apparatus has not yet been attained by the Braun system, it may be assumed that in the course of time the two German systems will reach the same degree of perfection.

As a result of these trials the Emperor has ordered that the Slaby-Arco system be definitely and exclusively adopted for the German navy.

In the German navy estimates for 1902 it is stated that, owing to the the successful trials of wireless telegraphy, the new ships and important stations should be so fitted and an estimate of 6,000,000 marks was made for this purpose. One-half of this, or 3,000,000 marks, is required for the fiscal year 1902.

In connection with the discussion on syntony, it is interesting to note that last summer, when the German squadron, homeward bound from China, was off Ouessant in France, that the wireless signals being exchanged between the vessels were intercepted and read by the French coast stations. It is claimed that the French stations were enabled to communicate with each other concurrently with their reception of the German signals.

Great Britain continues to be the leading exponent of wireless telegraphy for naval purposes, and practically all large British vessels are equipped with the system, and at the torpedo depot ship *Vernon* the subject is thoroughly studied. Though the Admiralty pay a royalty to Marconi for the use of his system their instruments are modified and arranged according to their own specifications and system. Last July an order was given for 54 complete sets of the gear, to be completed in three months, and the order was apportioned to three different electrical firms.

The Admiralty some time ago decided to supply wireless telegraphic apparatus to all the battleships in the Mediterranean Squadron and most of the cruisers. There are a good many sets of the apparatus now in use on that station, installed generally as follows:

The first thing that is necessary before setting up the operating

table is to choose some suitable place, such as a spare cabin or chart house, through which the aerial wire may be led without risk of its sparking through to earth.

In the case of a chart house or signal house on the upper deck this is, of course, easy enough to prevent, but when it becomes necessary to lead the aerial wire through the deck there is need for very thick insulation; the method most in vogue is to cut a hole of a diameter of about 4 or 5 inches through the deck plates, lining it with a half-inch ebonite tube. This tube stands up from the deck to the height of 16 inches, and is sheathed from the wooden planking upward with brass to protect it from injury; it is capped with a thick disk of ebonite. The aerial wire is led through this after being well insulated with india rubber and oiled silk, the insulation gradually tapering off as it leaves the tube in such a manner as to give the impression from which it has earned the name of "cow's tail." The space between the insulation and the ebonite tube is filled with melted paraffin wax.

The "cow's tail" having been made and fitted, the aerial wire is measured off to the required length and led through large plates of ebonite to a spar projecting far enough outboard to give the wire a clear lead up to the spar at the masthead. The use of both these spars is chiefly to keep the aerial wire clear of wire rigging or ropes, which, in damp weather, would make "earth." Ebonite insulators protect the aerial wire from contact with the spars.

In many ships the wire is looped so that the end turns back upon itself, and is spliced to its own part close to the outrigger spar, the object being, of course, to obtain greater capacity for the same height.

So much for the aerial wire; we now turn to the other end of the "cow's tail," which is led into the operating room and joined up to one of the brass balls of the induction coil. The other ball of the coil is joined to earth by means of a vertical wire coiled in a spiral and soldered to one of the iron beams.

A much thinner wire coiled into a spiral form also comes from the "cow's tail." This is the receiving lead from the aerial wire and comes down to the keyboard.

Seven accumulators are generally used to work the coil.

The key is grasped by the long ebonite handle, and a succession of longs and shorts made with it is reproduced in sparks between the two brass balls connected with the aerial wire and earth, respectively, setting up oscillating currents in the wire and thus sending out the so-called Hertzian waves.

A small block with a hole in it is placed on the side of the receiving box. This block is made of ebonite and is intended to receive a small spur on a long arm that extends from the signaling key.

It is this arm which switches the aerial to "send" or "receive." In the "receive" position the thin spiral wire from the "cow's tail" is

put in connection with the receiving box; if, however, the arm were swung over to "send," the whole receiving box would be cut out of circuit with the aerial wire.

We shall now consider the receiving circuit and trace the current from the thin spiral wire.

The receiving box is covered with a brass sheath, the object of which is to intercept any local electro-magnetic waves that might proceed from sparks in the neighborhood and directly affect the coherer, rendering messages unintelligible. Hence it will be seen that the box is kept shut when in use.

The lead from the aerial wire enters the box and picks up the primary of the "jigger;" this jigger is earthed through the box. The secondary of the jigger is divided into two coils, its two outer ends being brought to the two outer terminals of the row of four. These outer terminals are connected to the coherer, while the two inner ones, representing the two inner ends of the primary, lead through choking coils, one to the relay direct, and the other through one of the cells of the battery of "Obachs," and so to the relay.

The relay is inclosed in a cylindrical case, the choking coils are inclosed in the box which contains the jigger, below the group of terminals. The outer terminals, as we have seen, are joined to the coherer. The local battery circuit consists of the remaining 9 cells, or, rather, 8 cells, for one is usually kept as spare. The connections of the local battery are tucked away out of sight, but it will be sufficient to say that the Morse inker, alarm bell, and tapper are forked into it.

Shunt coils are put into the tapper circuit to prevent sparking at make and break.

The operating table is covered with sheet india rubber, and the whole apparatus can comfortably be worked in a space of about 4 feet by 2 feet. A common dodge for testing the sensitiveness of the relay consists in slightly moistening the fingers and touching the two center terminals of the group, when the tapper should buzz. Should the relay be too sensitive, the single cell will have power enough to keep the tapper in vibration after it has once started, and this must be carefully guarded against; it is one of the most difficult adjustments to be made, and once obtained should not be altered unless absolutely necessary; a continued buzzing of the tapper often shows a defective coherer, i. e., one which offers too little resistance in its decohered state. Many coherers are supplied, and they are easily exchanged.

Signals of course can be taken in by simply listening to the working of the tapper; it works exactly with the tongue of the relay, and consequently with the inker.

Signals must be made slowly; it is possible to make a "short" so short that the tongue of the relay has not time to go over, and consequently no record is made.

The whole apparatus can be fitted up in a ship in a very short time, one forenoon may suffice, but the adjustments often take a long time to get in order, and there are so many possible causes of faults that it generally pays to do everything in "slow time."

With the apparatus described signals have been received at a distance of 120 miles.

The distance of transmission of H. M. S. *Argonaut* noted before and the 162 miles communication of H. M. S. *Arrogant* have been exceptional. Generally there has been nothing like as good as this accomplished. During the voyage of the channel squadron from Gibraltar to Berehaven, last fall, it was found that the vessels could send signals up to 100 miles, but could not receive intelligibly at more than about 40 miles.

During last summer's maneuvers wireless telegraphy played an important and disastrous part, betraying absolutely its users and affording a most significant proof of the vital necessity for some reliable form of syntony, or other means of preventing the interception of messages. The following from a correspondent of the London Telegraph on H. M. S. *Magnificent*, August 7, shows what happened:

Throughout the operations we availed ourselves largely of wireless telegraphy, but not in the manner generally anticipated by any means. Our installations were continually at work, it is true, but not passing messages to our consorts. They merely listened, harvesting the crop of communications that our foe was industriously sowing broadcast. When a message is tapped out by the Marconi system it is as though one threw a stone into a pond. The electric "ripples," if one may call them so, spread outward in rings, and will affect any receiver, east, north, south, or west.

The English Channel was alive with the enemy's messages. Anyone could pick them up who would. We played the part of eavesdroppers. If Admiral Noel's flagship whispered sweet nothings or momentous somethings to a distant friend the chances were that we were near enough to overhear. Without warning the bell in the operating room would tinkle merrily as soon as the impulse affected our installation, and then the whole story would be poured into our ears without reserve. The foe may have had their doubts about the secrecy of their messages, but if so they were apparently allayed when they found themselves catching little from us. They were not aware that we were communicating little between our own ships by this means, so that our attention might not be diverted from the unconscious confidences of our opponents. We had the system installed on board the battleships *Majestic*, *Magnificent*, *Jupiter*, and *Hannibal*, and the cruisers *Niobe*, *Diadem*, *Arrogant*, *Furious*, and *Pactolus*, and with varying success they were drinking in the enemy's secrets. The foe communicated in code, and at first this might seem somewhat of an obstacle to our little game. But no. After a short interval for study of the cryptograms, it was clear as noonday that they were using a code we had by us with some variations. The problem was soon solved, and we kept our ears to the keyhole with excellent results. Did the enemy's main fleet coaling at Portland tell its thoughts to its base at Portsmouth, we, lying out of sight south of Portland Bill, drank in all the confidences, and neither sender nor receiver was any the wiser.

This occurred before the war, but after hostilities commenced we continued the same policy. When at Guernsey we deciphered messages sent by Admiral Sir Gerard Noel's ships 80 miles distant. On the morning of our great battle off the Lizard it was one of our opponen^d cruisers which asked the *Revenge* where she was

and enabled us to learn Admiral Noel's bearings from his own flagship. So we played the game merrily and persistently, and the enemy wore his heart on his sleeve for us to study.

During a recent cruise of H. M. S. *Revenge* along the Irish coast the battleship received a number of Marconi messages passing between mail steamers and the shore. It is stated that the admiralty proposes to make an attempt to intercept wireless messages from various experimental stations, with the idea of proving the value of Marconi's claim to exclusive syntony.

A new source of danger to be guarded against with wireless installations on ships was demonstrated on H. M. S. *Glory* in Hongkong harbor in August last, when the aerial wire was struck by lightning and wrecked, about two-thirds of the apparatus becoming detached and crashing to the deck. Fortunately, it being night, few were about and no one was injured.

Italy, the birthplace of Marconi, was, as is well known, one of the first to organize official experiments in wireless telegraphy. In fact it was in July, 1894, that the first experiments in Italy took place, in the first instance at Rome, between two different floors of the offices of the naval administration, and afterwards at Spezzia, both trials being under the direction of Marconi himself, who had been expressly invited to come to Italy by the authorities of his country and at the initiative of several of the superior officers of the army and the navy.

Successful results were obtained from these tests; battleships of the Italian navy communicated with the coast of the peninsula at a maximum distance of 16 kilometers, with antennæ of 22 and 34 meters.

Since then experiments in wireless telegraphy have continued uninterruptedly in Italy at the instance of the ministers of the war office, and especially of the naval administration, to whom Marconi at the time of his experiments at Spezzia had given permission to use his apparatus, and also all the improvements and additions which he might subsequently design for his instruments, which at that time were necessarily primitive. The experiments in question were at first directed by M. Pasqualine, electrician in chief to the navy, and by M. Civita, engineer. During the first set of experiments, which cost the Italian Government about 100,000 francs, very interesting results were obtained. Several battleships were fitted with the apparatus, many stations were established on the Italian coast, and communication was effected at a maximum distance of about 100 kilometers between a vessel out at sea and a fixed station on the coast.

When Messrs. Pasqualini and Civita retired from the Italian navy the wireless telegraph service was intrusted to the officers themselves, among others to Commander Pouchain, now chief of a division in the navy, and to Lieutenant Solari, who recently proposed to the

administration to connect Pekin with the bay of St. Mun by wireless telegraphy with the aid of several relay stations, or Guarini repeaters.

Then followed some unsuccessful experiments—for instance, between Messina and Reggio, at a distance of a few kilometers; but we also heard of signals reaching English battleships off Malta, having been sent out by Italian battleships off Sicily, the distance between them being about 200 kilometers.

Japan is making wireless experiments under the direction of a committee appointed by the navy department for this purpose. The first experiments were conducted in February, 1900, over a distance of $8\frac{1}{2}$ miles, between the naval academy at Tokyo and a temple at Anamori, Haneda, using a height of wire of 75 feet. As the results were satisfactory further trials were undertaken during the naval maneuvers at Kobe in April. Later trials between Tokyo and Yokusuka (27 miles), and later over 50 miles, have encouraged the authorities to further installation at Tokeshiki Naval Station, at Cape Shishimi, and other points about the coast and on vessels.

Russia has made use of the Popoff system. This is practically identical with the Ducretet, or, as it is often called, Ducretet-Popoff system. This has been definitely adopted for its Black Sea and Baltic fleets, and is also to be applied extensively in the Pacific.

Spain has been engaged in some interesting tests between the mainland and her colony of Ceuta. They are described as follows by E. Guarini in *The Electrician*, April 18, 1902:

WIRELESS TELEGRAPHY IN SPAIN.

By E. GUARINI.

In September, 1899, Señor Julio Cervera Baviera, a commandant in the Spanish engineers, presented to the ministry of war a résumé of his electrical work and a description of the instruments used for the transmission and reception of signals by means of electromagnetic waves and its application to wireless telegraphy. A commission of generals and officers of the engineers was appointed to examine the apparatus in a complete system. Tests were made first at Madrid, then between Madrid and the military polygon of Caracanchel, and later on between Madrid and Escorial. The first tests having been satisfactory, at the beginning of December, 1899, official experiments were made in the presence of the King and Queen Regent, the war minister and the King's aids-de-camp and professors, and numerous generals and engineer officers. At that time Commandant Cervera was charged by the war ministry to continue his studies in the application of his system. In 1899 he made experiments between Ceuta, on the Strait of Gibraltar, and Algeciras. Later, in 1900, he continued his work at Valence. The apparatus, which we briefly describe, is that which Commandant Cervera employed more recently in the second term of 1901 between Ceuta and Tarifa. The Tarifa station is on the Mount Comorro at an altitude of 47 meters. The Ceuta station is situated at the Castle of Hacho at 180 meters altitude, the difference in level between the two bases thus being 133 meters. The Tarifa mast is 51 meters high and the Ceuta mast 56 meters high. It will be noticed that the height of the masts employed is considerable, especially compared with the practice to-day, when one can communicate with very short cylinders (see

The Electrician, February 15, 1901, and English patent 1555, of January 24, 1900), but Commandant Cervera observed that the height of the masts is not a necessity in these communications, although it has a purpose in view of other applications in the navy. Between Ceuta and Tarifa all systems and processes of wireless telegraphy which were known in Europe were tried, so that a comparison with the Cervera system might be established.

Señor Cervera's transmitter is indicated diagrammatically in fig. 1. So that the same air wire and earth connection should serve for the transmission and reception of signals, a switch was employed which connected the air wire to the earth connection in such a manner as not to include in the circuit the two condensers. The interrupter employed in the primary of the induction coil is a special pattern invented by Señor Cervera, with solid contacts immersed in petroleum, which is contained in an

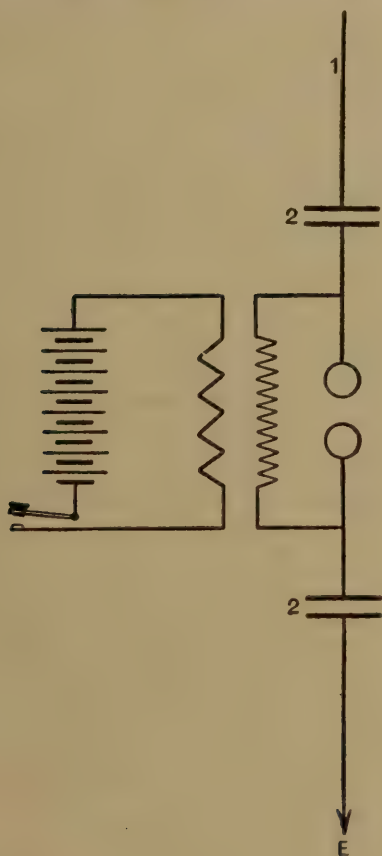


FIG. 1.

1. Silk-covered copper or steel air wire, 0.2 mm. diameter.

2. Condenser suited to the distance and to the capacity of the air wire. These condensers are constructed by a special process, and are inclosed in wooden or ebonite boxes.

ebonite box. It produces 100 interruptions per second. The key is also of a special design. First, Señor Cervera employed a keyboard as described in his English patent No. 20084 of 1899 (October 6). This was similar to that of a typewriter. By pressing down the key corresponding to the letter or signal to be transmitted, dots and dashes were transmitted representing that letter in the Morse alphabet. More recently, probably because this keyboard was too complicated, although most ingenious, Señor Cervera used another form of key, whose object is to eliminate completely the spark when the current is broken. This is done by connecting to earth the two points at which the circuit is interrupted, the connection of one being made directly and the other through a condenser. The object of the condensers interposed between the air wire and in the earth connection is evidently to increase the

energy of discharge (CV^2) by increasing the capacity C of the circuit. These condensers, Señor Cervera points out, are indispensable when the transmitting wires are very thin, as are those he has employed. Señor Cervera thinks it is advantageous to employ a very fine air wire on account of its small weight and the facility in handling.

The Cervera receiver (fig. 5) has several remarkable features, some of which are very advantageous and useful, and others whose utility and advantage appear to me very problematical. It consists of an air wire (the same as that employed for the transmission) connected to earth through the primary of an induction coil. The secondary of this coil, divided exactly at its center by a condenser, ends in the coherer electrodes, which are of very soft annealed iron. The coherer is put in circuit—through the contact point and the armature of a ringing apparatus—with two adjustable resistances, a battery and a relay. This latter closes the circuit of a battery, an adjustable resistance and a second relay. Señor Cervera calls the second relay a multiplying relay. It has four functions: (1) To work the Morse apparatus, (2) to interrupt the current of the battery and coherer and to make the decohesion of the latter easier, (3) to work the tapper which decoheres the sensitive tube, and (4) to interrupt the current through the electro-magnet which regulates the sensibility of the coherer, for the purpose of facilitating the decohesion of the latter. As is seen in fig. 5, this tapper acts both as a decoherer and interrupter of the current passing through the coherer and the first relay. It is also seen that the tapper, the Morse instrument, and the electro-magnet which regulates the sensibility of the coherer are each actuated by a separate source of electricity.

Señor Cervera has also made conclusive tests with an arrangement in which the air wire is insulated from the earth and is connected through solenoids, one of which is the primary of a small transformer, for raising the pressure of the coherer circuit, and the other of which is wound around the soft iron electrodes of the coherer. The secondary of the small transformer is divided into two parts by the circuit of the battery and relay which are interposed in the coherer circuit.

The coherer generally employed by Señor Cervera is made as follows: Between two small parallel ivory disks, whose distance apart can be adjusted at pleasure by means of three fine screws, are the metallic poles which press against the filings. These two poles have two wires or strands of well-annealed soft iron, which are the two branches (one being a prolongation of the other) of the coherer core. The length of each of these branches varies from 4 to 6 centimeters and the diameter is 2 millimeters. An ivory disk, with a circular orifice at its center, contains two other ivory disks which press against the filings.

Other experiments have been made in Spain by the firm of Rochefort, who have put up a permanent installation between Cadiz and Matagorda for the Compagnie Transatlantique. The feature of the Rochefort transmitter is the employment of a unipolar transformer. The receiver includes a double tapper, tapping the coherer both in its go and return motion, and it also includes a system of regulating the coherer by varying the distances between it and a permanent magnet. This system seems to have been mentioned by Brown in the patent mentioned above.

Sweden and Norway have been testing the Slaby-Arco systems, and as a result of these tests appear to have adopted it definitely. Trials were made at Christiania last year with the men-of-war *Frithiof* and *Eidsvold*. Good results were obtained. One of the vessels remained at the military port of Harter while the other steamed through the fjord. With masthead heights of 85.3 feet they communicated without difficulty through a distance of 13.6 miles. On the open sea the vessels communicated easily at twice the distance without increasing the heights of the wires.

A lieutenant-colonel in the Swedish army, Mr. G. Baunerhjelm, has for some time experimented with wireless telegraphy (Marconi's system). It is claimed that he has recently made improvements in this

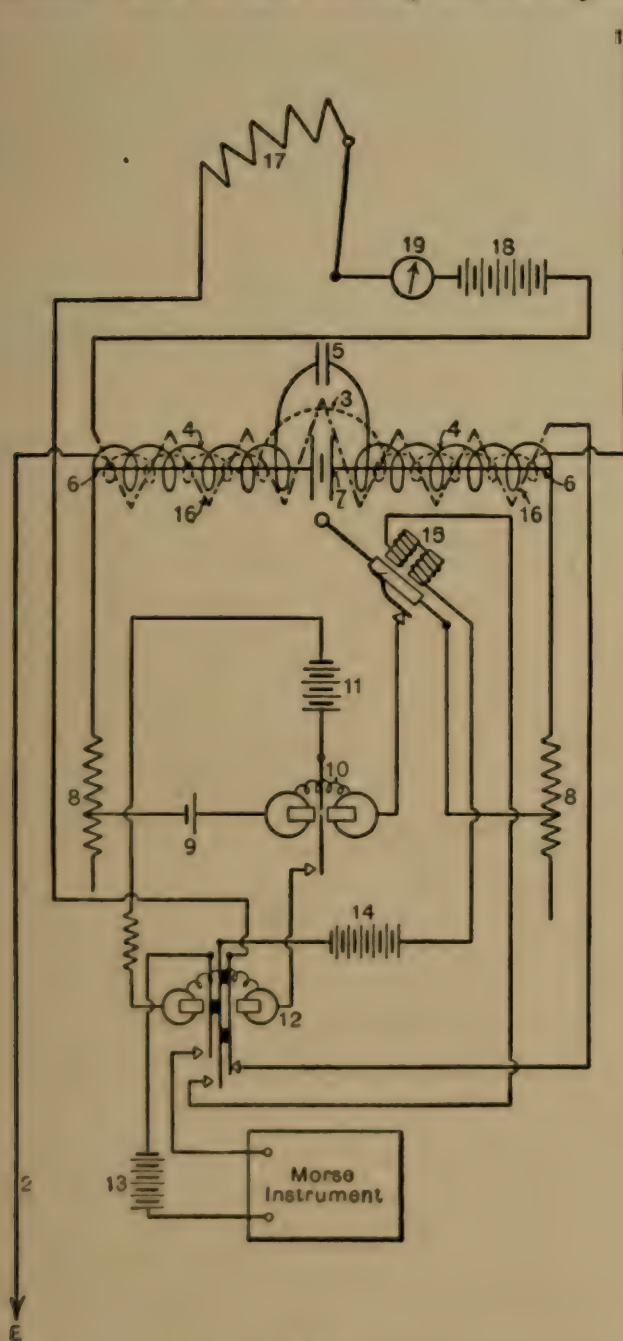


FIG. 2.

- | | |
|---|---|
| 1. Air Wire. | 11. Battery of the circuit closed by the relay. |
| 2. Earth connection. | 12. Multiplying relay. |
| 3. Primary coil of the transformer. | 13. Battery for Morse instrument. |
| 4. Secondary coil of the transformer. | 14. Tapping battery. |
| 5. Condenser. | 15. Tapper. |
| 6. Soft-iron electrodes in connection with the secondary coil - 4". | 16. Winding of electromagnet regulating the sensibility of the coherer. |
| 7. Coherer. | 17. Resistance to regulate the sensibility of the coherer. |
| 8. Adjustable resistance. | 18. Battery for the regulating electromagnet. |
| 9. Battery of coherer circuit. | 19. Milliamperemeter. |
| 10. First relay. | |

line which, if practical, will be useful for military purposes and at sea. The newspapers state that he has invented an electric radiator or reflector which, combined with the Marconi system, can send the elec-

tric waves, and with them the message, in the desired direction. There is not at hand any description of the apparatus, which is now being tested by Swedish experts, but its construction is said to be based on the theory that electric waves are reflected by metallic surfaces. The drawback of the system seems to be that a telegram can not be sent in a certain direction a longer distance than 25 or 30 miles, but for many purposes this may be sufficient. The experiments will be continued, and further improvements may be made.

WIRELESS TELEGRAPHY OF THE SLABY-ARCO SYSTEM (GENERAL ELECTRIC COMPANY, BERLIN), 1902.

PART I.—DESCRIPTION OF THE SYSTEM, FORMATION OF THE VIBRATORY SYNTONY, AND SHORT DESCRIPTION OF NECESSARY APPARATUS.

THE RECEIVER.

The theoretical bases of the new method, published in the *Elektrotechnischen Zeitschrift*, Book 2, 1901, have been discussed by Professor Slaby in his lecture on attuned and multiplied wireless telegraphy on December 22, 1900 (see No. XX, p. 319), in the conference room of the Allgemeine Elektrizitäts-Gesellschaft. We now propose to repeat only certain passages of his lecture necessary to an understanding of the connections.

When electric vibrations unite (fig. 1) in the direction indicated by the arrow, on a vertical receiving conductor, connected below to earth, the latter enters in vibration in such a manner that in the vicinity of the point at the earth, B, is formed a node of the electric waves, and the amplitude between B and A, following the law of sines, increases until finally it reaches in A an arc of tension. This vertical conductor, B A, possesses, proportionately to its own induction and its capacity in relation to earth, a certain vibration of its own. When the impulse of the transmitter arrives in a different measure, for instance, more slowly than the proper vibration of A B, there will be interposed immediately above the point at the earth, B, an automatic induction, through whose determined amplitude of vibrations the receivers' own vibrations will be equalized with those of the transmitter. In other words, the receiving conductor will be syntonized with the transmitter.

The receiving apparatus proper is supplied with sensitive vacuum coherers with patented angular filings to record the waves. These coherers are varied according to the distance of transmission.

As is known, a coherer is influenced by high tension discharges. To bring about in it the greatest possible change of tension, a second system syntonized by the receiving conductor A B will be put in vibration, its indicator being accurately localized; in other words, localized in such a manner that one of its poles shows a potential of change of great amplitude, while the potential of its other poles, through connection with a source of current or with earth, is kept constant, so that between the two poles there exists the greatest possible difference of potential.

This takes place in a connection as shown in fig. 2. To the syntonizer receiver A B there will be connected a conductor, C D—C A, immediately above the earth point A B, therefore, at a point where the amplitude of the waves is very small. When these two conductors coincide electrically there is produced at D an amplitude almost equal to that produced at A.

The effect will be better if the length of wire is wound in a convenient form than if the wire were disposed in a straight line. Fig. 3 shows such an arrangement. It is the form mostly employed in the receiving connection of our system.

The coil M, of a special form and winding, produces at D, at the waves indicator, a tension arc whose amplitude is much greater than that at A. For that reason it has been called by Professor Slaby, "Multiplier of tension." The other letters

used in fig. 3 have the following meanings: F signifies coherer; K, a condenser placed in the receiving apparatus to which are connected in parallel the low tension element P and the relay R. The capacity of K is about 100 times greater than that of the coherer.

In this system the electric vibrations of the ether equalize practically at A and B alone, without causing any vibrations at the point C, and consequently they seldom cause any disturbances at F, making an opportunity for further improvement in absolutely preventing them by means of other connections, which are sometimes used. As those connections are complicated, we will only mention them (figs. 4 and 5) without going into details as to the nature of their effects.

It should be observed that in the connection, as in fig. 4, the varying capacity of the coherer almost possesses an influence upon the accordance, because it is in a system of tertiary vibrations; and that in the connection, fig. 5, no communication between the earth and the receiving apparatus is made.

The practical advantage of all those receiving connections, as already mentioned, consists, firstly, in the exclusion of atmospheric disturbances; secondly, in the possibility of making available the already existing vertical conductors connected to earth at their lower extremities; and thirdly, in the considerable increase in the intensity of reception obtained through a very pure accordance.

It is claimed for the receiving apparatus of this system that they are remarkable for their service stability and reliability. As they work in the open without any metallic covering, any derangement in the service may be noticed and repaired.

THE TRANSMITTER.

The Slaby-Arco transmitter is equipped in a manner similar to the receiver. In this is also employed a vertical conductor connected with earth. The electrical sequence is the inverse of that of the receiver. Whilst in the latter the syntonizing receiving conductor is put in vibration by the distant effect, and thus through this vibration proper vibrations of great amplitude are produced, in another secondary system of small capacity, comprising the indicator, just the reverse takes place in the transmitting apparatus: the transmitting conductor connected to earth is excited to produce proper vibrations by means of a primary system accorded with the proper vibrations of a greater capacity, but of a lesser amortization. Fig. 6 shows the transmitter in its most simple form. The coil S serves to regulate the fundamental tone of the transmitter to emit a selected wave length, and besides to obtain at B a sufficient amplitude of reception. F is the length of the excitation spark, C D a horizontal induction coil of proper induction and of syntonized capacity. For the final regulation of the vibrations of the exciter it is impossible to obtain any increase of the effect.

This transmitter permits of an exceedingly strong accordance with the receiver. Moreover, the aerial wire directly connected to earth, conducts only a very small but sufficient tension, physiologically not at all harmful in amount. Its degree of electric usefulness is very favorable.

Fig. 8 shows this transmitter in a somewhat different construction, the one employed in installations with difficult wiring arrangements.

For instance, it is next to impossible with the former type of connections to install the apparatus below an armored deck, because the introduction of a transmitting wire carrying a higher tension current is accompanied by insurmountable technical difficulties. In the compartment for the apparatus, they then place the exciting circuit connected to the earth at K, which contains an automatic induction S, the condenser K, and the exciting spark gap F, and then to the circuit above the deck by the junction wire C D, which with its insulation of 3 millimeters (0.118 inch) may be installed like any ordinary wire. The multiplier M is then placed upon the deck in a water-tight box, with spark distance F, to which is joined at B the transmitting conductor. While in the conductor C D there exists a tension of about 15

millimeters spark distance, the latter is increased by the multiplier to an extensive degree, and rise at B, for example, to 150 to 200 millimeters.

The transmitter's apparatus are principally the following:

If they have alternating current at their disposal, they feed the source of high tension—the inductor—directly without interruption with current of the same character. This system, from the point of view of electric intensity, as well as regards simplicity of arrangement, is the most advantageous. Between the source of current and the inductor there will be interposed only one Morse manipulator with platinum contacts and a spark arrester. In place of condensers they use very small Leyden jars in papier-maché or mica boxes, steadied against oscillations. The number of jars is regulated according to the electric conductor of the source of high tension at our disposal and the length of the transmitting wire, and increases with both. The spark and gap is so built that no sound penetrates it, and is fixed to the cylinder of the Leyden jars. The apparatus can be regulated during its operation.

With continuous current they use their patent mercury turbine interrupter, which on board of vessels is hung up in its box in such a manner that it receives electric energy from all possible directions. It is able to interrupt relatively great primary inductions.

PART II—DESCRIPTION OF APPARATUS.

According to the different modes of employment are furnished two types of stations:

1. Normal stations for ship and shore purposes in three different designs—for small distances of up to 40 kilometers (24.85 miles), for medium distances of up to 80 kilometers (49.7 miles), and for long distances of exceeding 80 kilometers (49.7 miles) across the sea.

2. Light movable shore stations, with microphone receiver and telephone.

These two types, as a whole and as single apparatus, are described and illustrated in the following pages.

A.—APPARATUS OF TYPE 1 (NORMAL SHIP AND SHORE STATION).

A complete station is shown in fig. 9, and consists of the transmitter and receiver.

(A) THE TRANSMITTER.

(a) *Low-potential circuit.*

The arrangement of this circuit is shown in fig. 10.

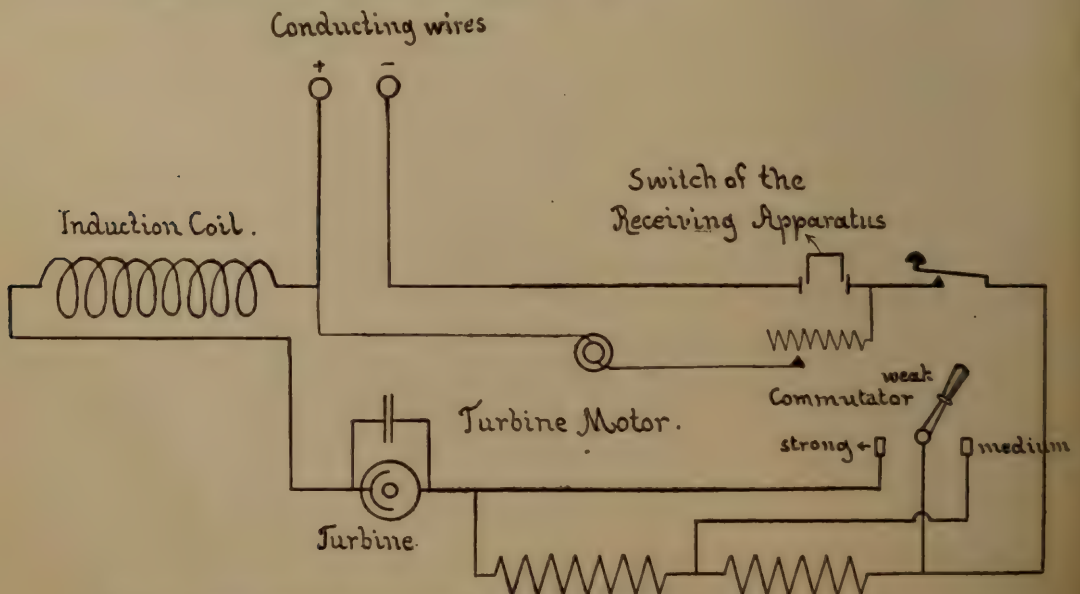
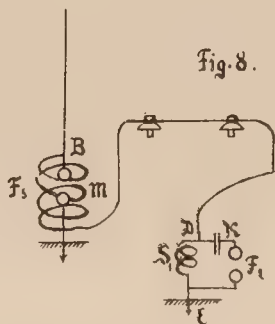
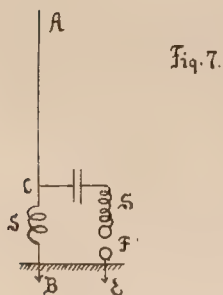
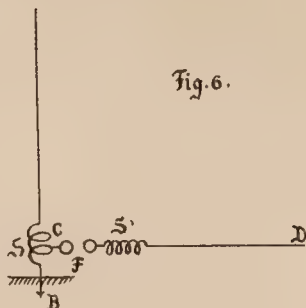
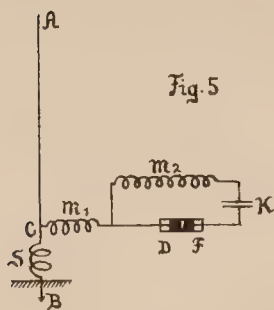
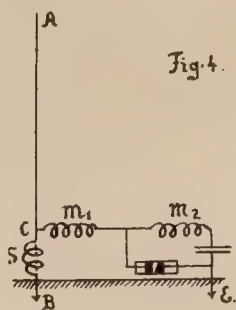
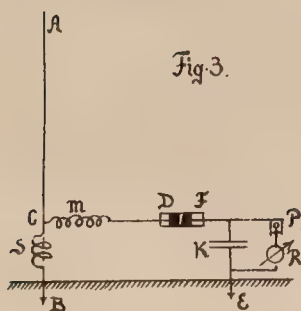
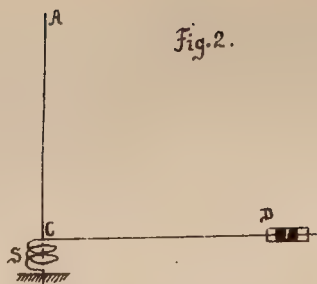
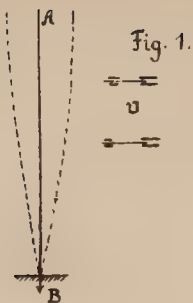
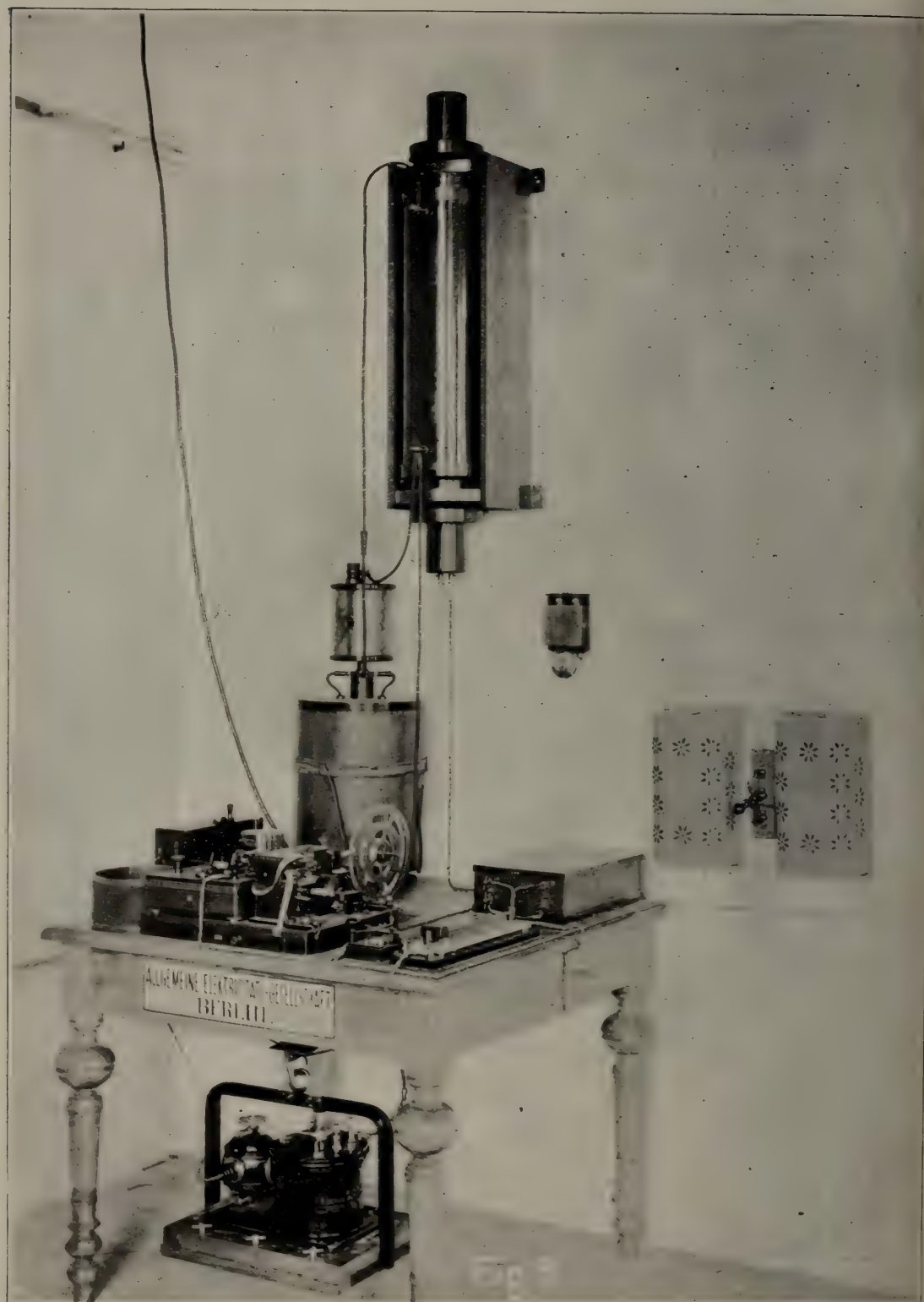


FIG. 10.—Low-tension circuit with receiving switch and resistance for weakening.



System of Transmission and Reception.



SLABY-ARCO WIRELESS SYSTEM.

The different apparatus placed into the low-potential circuit are as follows:

1. The induction-coil.
2. The primary condenser.
3. The mercury-turbine interrupter, with motor and slide resistance.
4. The Grisson continuous current-alternating current transformer.
5. The Morse key, with magnetic spark extinguisher.
6. The three-step rheostat.
7. The device for protection from lightning.

1. *The induction-coil (fig. 11).*—The induction coils used for type 1 differ according to the distance to be bridged.

For short distances (up to 24.85 miles) are used induction-coils whose jump of spark is about 15 centimeters (5.9 inches), and which are contained in closed wooden boxes. They are equipped with the usual hammer interrupter. As source of current we use a battery of 20 to 40 dry cells of about 16 volts. The consumption of energy is from 50 to 100 watts.

For medium distances (up to 49.7 miles) we use induction-coils of about 30 centimeters (11.8 inches) spark length for a maximum load of about 1 kilo volt-ampères, fed either by continuous current with the use of a turbine-interrupter, or directly by alternating current.

The long distances (above 49.7 miles) the induction-coils have a capacity of 3 kilo volt-ampères and above, and are fed either directly by alternating current or by continuous current, with the use of a Grisson continuous current-alternating current transformer.

2. *The primary condenser.*—This condenser is put in the circuit parallel to the primary interruption spark of the induction circuit and inclosed in a wooden box. At the station it is located at any convenient place, usually in the vicinity of the interrupter.

3. *The mercury-turbine interrupter with motor and slide resistance (fig. 13).*—The mercury-turbine interrupter consists of a mercury-turbine actuated by a motor. The number of revolutions of this motor may be varied between 200 and 1,000 a minute. The vertically arranged hollow turbine shaft dips with its lower end into a cast-iron receptacle partly filled with mercury. The quantity of mercury is 3 kilograms (6.6 pounds). The mercury is sucked up by the turbine shaft through the rapid rotation of wings contained therein, and then squirted out in a horizontal plane through an opening of 2 millimeters cross section. A metal segment is arranged concentrically to the shaft. The latter is struck by the rotating jet of mercury during part of each revolution. As the mercury is conducted through conducting wires to one pole and the segment to the other, makes and breaks of the circuit are formed.

In order to extinguish the circuit-break spark rapidly the turbine receptacle is filled with alcohol, so that the spark occurs under alcohol. The length of the segment varies according to the voltage. At 110 volts, for instance, its length is 1 quadrant, at 65 volts 2 quadrants, and at 32 volts 3 quadrants. The mean intensity of the primary current at 65 volts is about 15 ampères with 20 interruptions.

For use on board ship the turbine interrupter is provided with cardan suspension.

4. *The Grisson continuous current-alternating current transformer.*—In place of the turbine interrupter we furnish, for larger electric efficiencies and in order to obviate the mercury-deposit cleaning, the Grisson continuous current-alternating current transformer.

The continuous current-alternating current transformer, Grisson patent, shown diagrammatically in fig. 12, takes the place of the continuous-current interrupter. The primary wire of the induction coil P has, besides its two principal binding posts P_1 P_2 , a third binding post P_3 , which leads to the center of the coil winding.

The principle of the transformer consists in first sending the current from the continuous-current source into the circuit P_1 P_2 and keeping it closed until a certain

maximum of current is attained. As soon as this is the case the circuit $P_2 P_3$ is also closed. As the two coils have a common iron core and magnetize in opposite directions, there is generated in the first circuit by the closing of the circuit $P_2 P_3$ an electro-motive counter force, which decreases the intensity of the first current and makes it approximately zero. At this moment the first circuit is interrupted, whereupon the current in $P_2 P_3$ in its turn rapidly increases to maximum intensity, etc.

In order to effect this automatic closing of one and the other circuit, or of both simultaneously, a contact device in the shape of a dynamo collector has been pro-

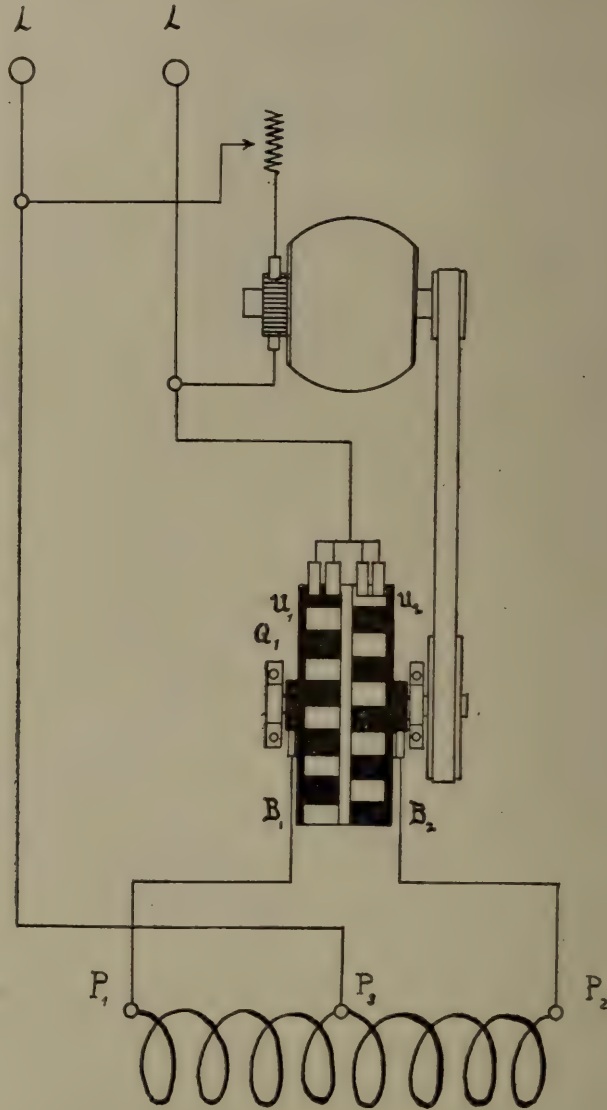


FIG. 12.

vided. This contact device consists of two contact wheels, $U_1 U_2$, insulated from each other and mounted on one and the same shaft, and which have on the one hand two continuous current conductors, $B_1 B_2$, and on the other hand a common brush, B_3 , which brushes alternately against the laminations of U_1 and U_2 , or at times connects both with each other.

The contact device is actuated by a small motor. The transformer does not supply pulsating continuous current, but pure alternating current, whose form of curve can be varied within wide limits. The number of periods can be easily varied from 15 to about 100. As no interruption of the currents takes place at maximum

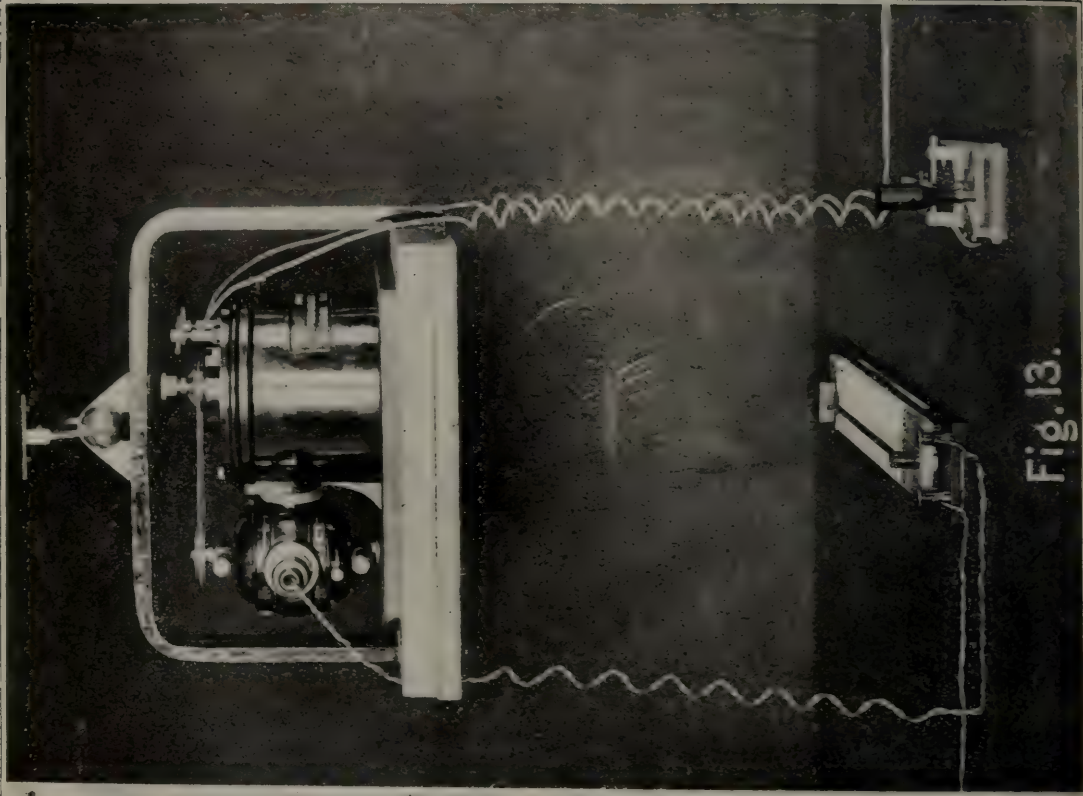
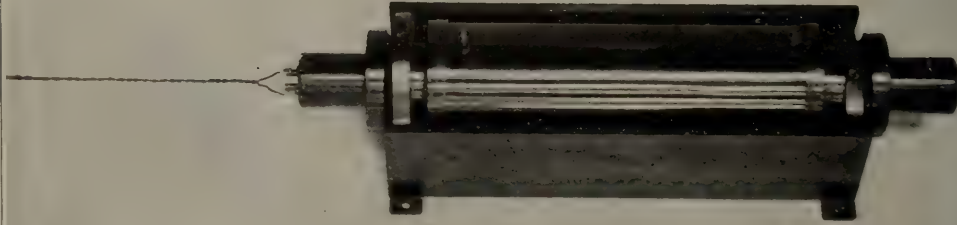


Fig. 13.

SLABY-ARCO APPARATUS.

Fig. 11, Induction coil; fig. 13, turbine interrupter.

intensity, and there are consequently no interruption sparks, or only small ones, it becomes possible by means of this transformer to employ currents of great intensity for feeding the induction coil.

Any normal induction coil can be used for the transformer by merely putting in the binding post P_3 .

5. *The Morse key with magnetic spark extinguisher (fig. 13).*—The result of currents of great intensity being interrupted has frequently been the burning out or fusing of the platina contacts of the Morse key, thus causing the most annoying interruptions in the operation.

All of these drawbacks are obviated by a patented Morse key with magnetic spark extinguisher in two designs, namely, with magnetic and with electro-magnetic spark extinguisher. The latter is so constructed that it can be easily secured to any normal Morse key.

6. *The three-step rheostat (for movable stations).*—The rheostat is placed in the circuit of the induction coil and serves to lessen the intensity of the transmitter when it is desired to signal over short distances.

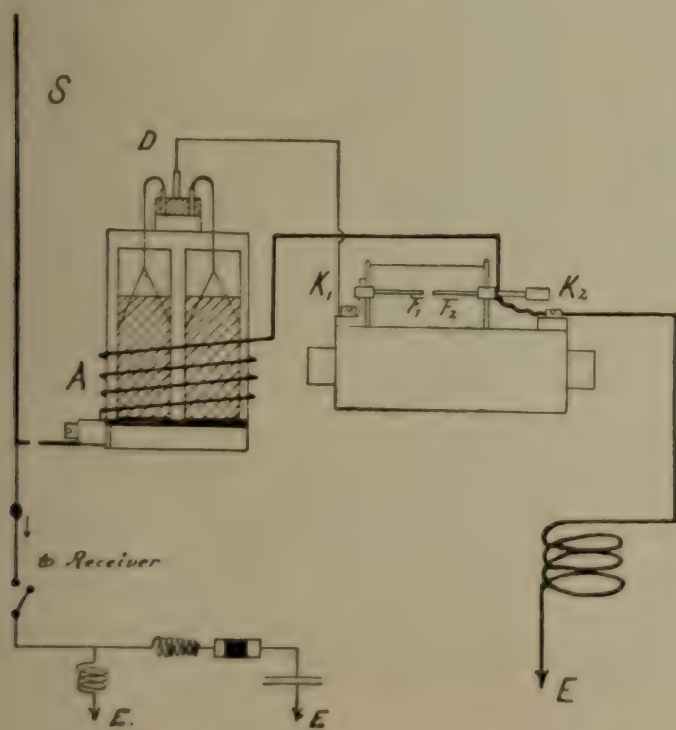


FIG. 14.—High tension circuit.

By means of a simple single-pole lever commutator in which the three positions of the lever are indicated by the marks of "strong," "medium," and "weak," no resistance, or one resistance, or both resistances are switched into the primary circuit of the induction coil according to the distance over which it is desired to signal. The voltage of the secondary coil is thereby reduced, expressed in spark-lengths, from 4.5 centimeters (1.77 inches) to 1.5 centimeters (0.6 inch), and 0.5 centimeter (0.2 inch).

The mean spark-length of 0.6 inch is usually sufficient for distances of up to 24.8 miles, the small spark-length of 0.2 inch for distances of up to 15 kilometers (9.32 miles).

7. *Device for protection from lightning.*—In order to prevent the insulation of the light machine from being endangered by lightning striking the low-potential circuit a lightning safety fuse is placed into the circuit.

(β) High-potential circuit.

The arrangement of the high-potential circuit is shown in fig. 14.

The different apparatus of this circuit are as follows:

1. The Leyden-jar receptacle.
2. The spark gap.
3. The transmitting cable.
4. The cut-out spark gap.
5. The exciter and tuning coils.
6. The thunderstorm commutator.

1. *The Leyden-jar receptacle* (fig. 15).—The receptacle contains 3, 7, or 14 double Leyden jars, and consists of a cylindrical box, between the upper and lower foundation plates of which the jars are secured in place by felt rings put between them. The casing of the box consists of a pasteboard or micanite cylinder.

The jars are double jars placed within each other, of a capacity of 0.001 microfarad each. Their outer coatings are connected with each other by a layer of tin foil on the lower wooden foundation plate. Their inner coatings are connected separately to a well-insulated collecting plate.

For transmitters of 20 meters (65.6 feet) length receptacles with three double jars are used, for those of 40 meters (131 feet) length seven double jars, and for lengths exceeding this fourteen double jars.

2. *The spark gap*.—The spark gap is set vertically on the collecting plate of the receptacle and surrounded with a pasteboard or micanite cylinder in order to deaden the sound. The ventilation of the interior of the same is effected by a hard-rubber tube on top. From both poles of the spark gap rubber cables lead to the secondary binding post of the induction coil, which is secured to the wall. The arrangement of the circuit is such that the upper adjustable pole of the spark gap is earthed and thus rendered harmless. The lower pole, the touching of which would have strong physiological effects, is made conspicuous by being painted red, and, owing to its hidden position, it is not easily accessible.

3. *The transmitting cable*.—It consists of one or more rubber-insulated strands and forms at its upper end (for about 10 per cent of its length) a cylindrical cage.

4. *The cut-out spark gap*.—It is located between the receiving wire and the exciter system and connected to the lower part of the Leyden-jar receptacle. Its object is, while receiving, to cut out automatically the high-potential circuit of the transmitter from the receiver.

5. *The exciter and tuning coils*.—They are wound on the cylindrical casing of the jar receptacle.

6. *The thunderstorm commutator*.—It is located in the circuit between the receiving wire and the apparatus room and serves to cut off the former at the approach of a thunderstorm.

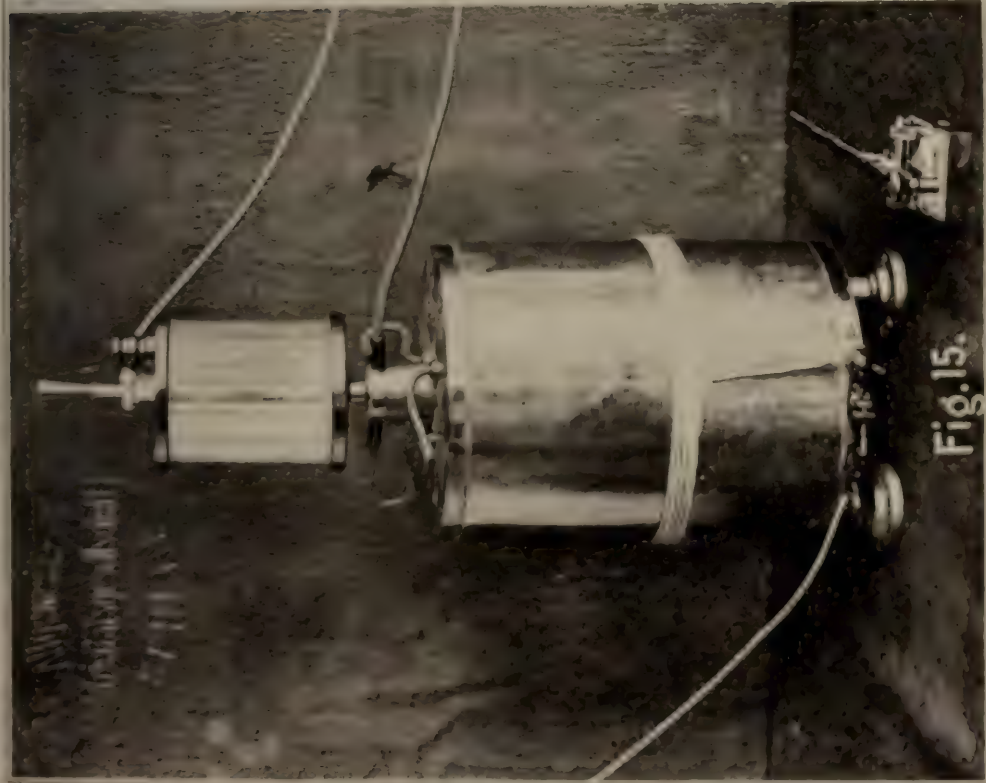
(B) THE RECEIVER.

The receiver is illustrated in fig. 16. Aside from the Morse recorder proper, the alarm and call bells, and the tuning coils, all of which are assumed to be generally known and will therefore not be specially described, the receiver consists of the receiving apparatus proper with the battery and coherer.

The receiving apparatus contains two separate circuits, namely, a weak-current circuit and a strong-current circuit (figs. 17 and 18).

In these figures the wires belonging to the weak-current circuit are indicated by — — — — —, those belonging to the strong-current circuit by . — . — . — . — . — .

Fig. 17 shows diagrammatically the course of the circuits; fig. 18 the actual manner of wiring.



SLABY-ARCO SYSTEM.

Fig. 15, Leyden jar; fig. 16, receiver.

(α) *The weak-current circuit (figs. 17 and 18).*

This circuit contains:

1. The coherer (A).
2. The interrupter (U).
3. The coherer cell (F).
4. The relay winding (R R).
5. The condenser (C).
6. The rheostat (W).
7. The switch for switching in and out (Sch).

1. *The coherer (A).*—Vacuum coherers only are used, on the one hand, to protect

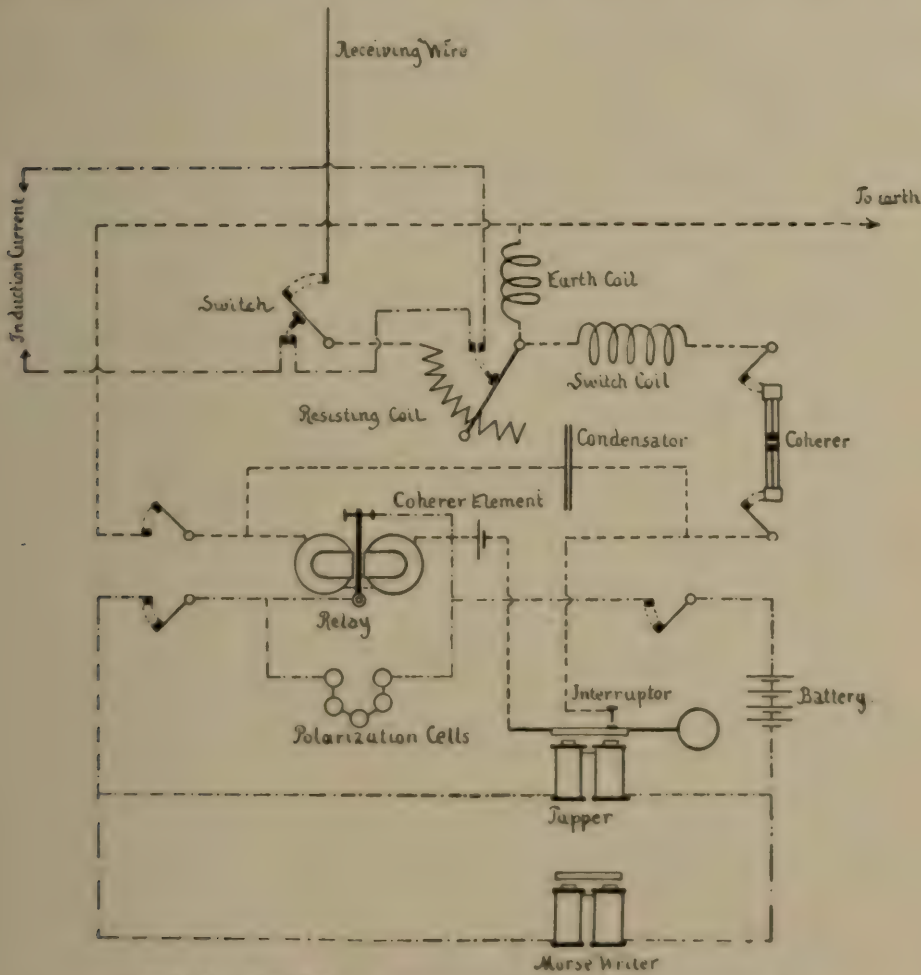


FIG. 17.—Switching arrangement for a receiving apparatus.

the metallic powder of the coherer from deterioration by oxidation from the influence of the atmosphere, and, on the other hand, in order to dry the powder thoroughly and thus keep it easily movable. Another advantage resulting therefrom is that the powder assumes similar grouping after each tapping of the tapper. The pistons of the coherers are of silver and very accurately fitted into the glass tubes, so that the very fine powder can not sift through between the piston and glass tube.

The conductors connecting the coherers are of strong platina wire and lead to metal caps secured with gypsum to the ends of the coherers.

The construction of the gap renders it possible to regulate the sensitiveness in spite of the air-tight closing. The front heads of the silver pistons are not parallel, but sloping toward each other, so that the gap formed is wedgelike. When the coherer is in such position that the narrower part of the gap is downward, the pow-

der fills the greater part of the same and the pressure of the powder increases. The sensitiveness of the coherer is then at its maximum. When, on the other hand, the wider part of the gap is downward and the powder thus distributed over a greater surface, the powder pressure decreases and the sensitiveness of the coherer is therefore at its minimum.

The coherer rests in bearings in which it is revolvable around its horizontal axis. A regulating wheel with pawl, secured to the coherer, renders it possible to give the coherer any desired degree of sensitiveness and subsequently to restore any predetermined sensitiveness each time. By this novel arrangement of tapper and coherer it has become possible to vary the sensitiveness of the latter even during telegraphing.

The coherer can be very easily exchanged, owing to the use of the metal caps for connecting them. Coherers of medium and high sensitiveness are used according to the distance over which it is desired to signal.

2. *The interrupter (U).*—The arrangement of the interrupter spring U is such that by the movement of the tapper lever, just before the ball strikes the coherer, the weak-current circuit is opened, thus removing from the coherer the voltage of the coherer cell. This arrangement effects, on the one hand, easier and more immediate disconnection of the coherer, and, on the other hand, greater durability of the same, since the weak-current spark formed at the tapping in the coherer and powder is transferred to the outside, namely, to the place of interruption U.

This arrangement has also made superfluous the noninductive resistances connected parallel to U which were necessary in other systems of circuiting hitherto in use.

3. *The coherer cell (F).*—It is a dry cell, whose voltage may be from 1.2 to 1.5 volts. At voltages above 1.5 the coherer works irregularly, while at voltages below 1.2 the sensitiveness of the relay is no longer sufficient.

4. *The relay winding (R R).*—The resistance of the coherer falls at normal intensity to about 2,000 ohms. Therefore the relay winding is given the same resistance, namely, about 2,000 ohms. The relay used is of the polarized type.

Its operation is about as follows:

A permanent steel magnet magnetizes, on the one hand, the iron cores $P_1 P_2$ within the coils in such manner that the upper pole pieces remain magnets of the same polarity, and, on the other hand, a soft-iron tongue, movable between these pole pieces in such manner as to give the tongue opposite magnetic polarity. This tongue is maintained in a certain position by two contacts $D_1 D_2$, D_1 being a rest contact, D_2 a work contact.

By changing the positions of D_1 and D_2 the tongue is placed in a labile magnetic equilibrium, resting against D_1 , when no current passes through the relay. When weak current from the coherer cell passes through the relay coil the magnetizing of one of the iron cores is increased, while that of the other is decreased. This disturbs the stable equilibrium of the tongue and causes it to strike against the work contact D_2 . By a counterweight, G, secured to the relay tongue, the latter is balanced in any position, so that the relay can be inclined 90 per cent toward the horizontal plane.

5. *The condenser (C).*—The condenser lies parallel to the dry cell and relay coil. Its capacity is 0.01 microfarad, hence infinitely high as compared with that of the coherer. It consists of sheets of tin foil insulated from each other by layers of mica. The condenser takes up the voltage shocks acting upon the coherer through the self-induction of the relay, and thus facilitates disconnection of the coherer. The earthing at E_1 is carried by the condenser (avoiding the self-induction of the relay) directly to the coherer through the interrupter U.

6. *The rheostat (W).*—It serves to reduce the receiving intensity of movable stations for the exchange of messages over very short distances. At the same time, by adjustment of its crank, the tuning is disturbed and the effect of the waves striking the coherer is reduced (choked). In order that the turning back of the crank at increasing distances may not be forgotten, it actuates simultaneously a cut-out for the turbine

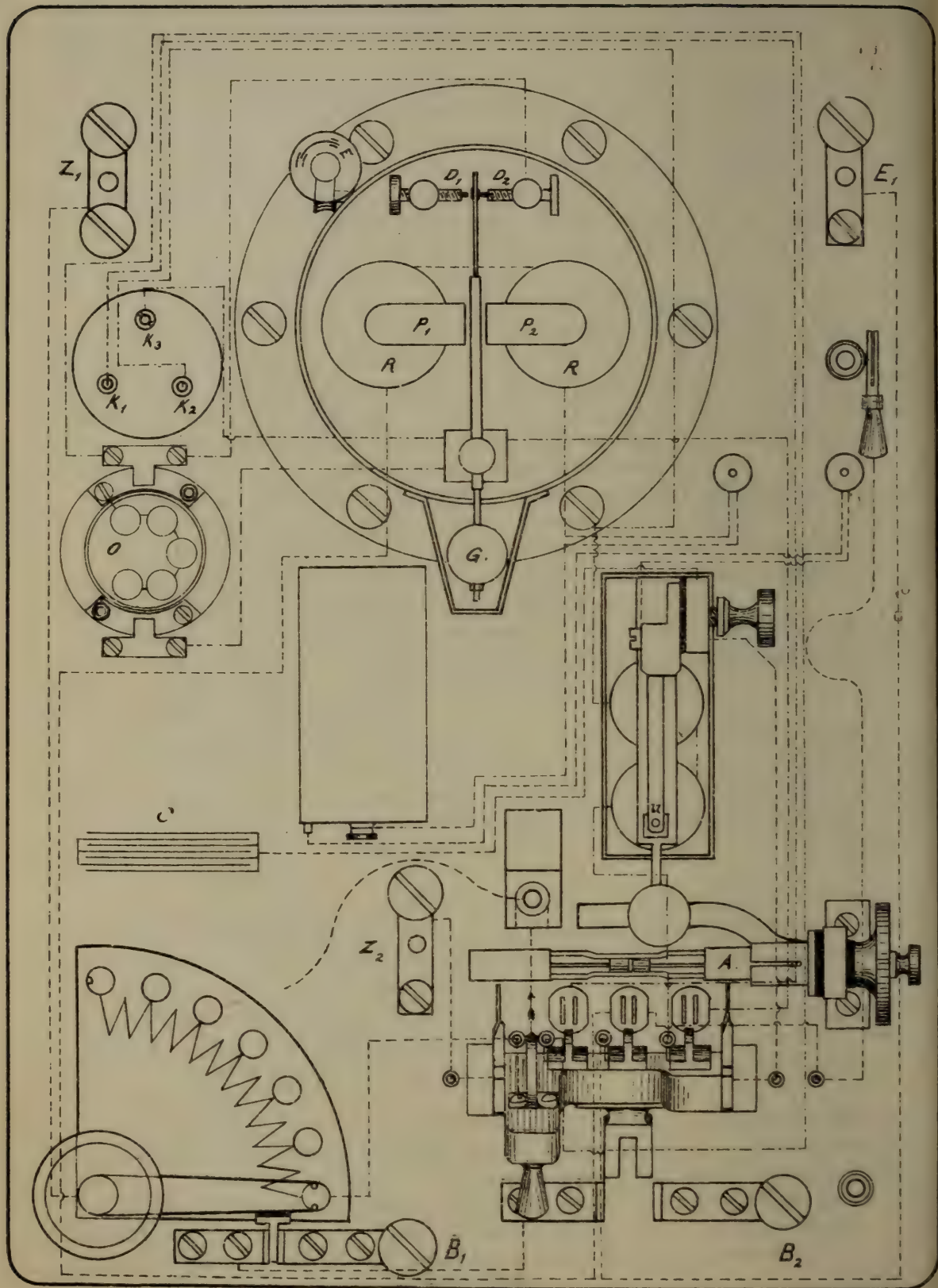


FIG. 18.—SWITCH ARRANGEMENT FOR A RECEIVING APPARATUS.

circuit, so that it becomes necessary each time before transmitting to place the crank at the initial position.

7. *The switch for switching in and out (Sch.).*—The switch closes and opens the following connections: The weak-current circuit to the coherer, the strong-current circuit to the relay, the high-potential circuit, and the earth circuit. All influencing of the receiving apparatus by the transmitter at the same station is thereby obviated. Short circuits in the strong-current circuit, which in other cases manifest themselves by sparking at the relay tongue, are thereby entirely precluded.

On the same cut-out there are in addition two contact posts, B_1 , B_2 , which are connected with each other when the switch is open and disconnected when the switch is closed. The primary current of the induction coil is conducted through these posts, the result being that if by inadvertence it should be forgotten to open the coherer switch for the purpose of transmitting, the induction coil will receive no current upon depression of the Morse key, so that no sparks are generated.

(β). *The strong-current circuit (figs. 17 and 18).* •

In the strong-current circuit are located:

1. The strong-current battery (not shown in diagram).
2. The tapper.
3. The relay work-contact D_2 and the tongue.
4. The polarization cells Q connected in parallel.
5. The Morse magnets (not shown).
6. The alarm device parallel to the Morse magnets (not shown).

The strong-current battery consists of 4 dry cells, which at first have a voltage of 6 afterwards one of 4 volts. The current starting from this battery (black connecting strand) passes through contact K_1 , which is on the receiving apparatus in the plug-box K , through the relay tongue, the work-contact, the tapping device, and thence through the second plug-contact K_2 back to the battery. As long as the relay tongue rests against against the rest contact D_1 , the polarization cells Q are connected in series in the strong-current circuit. When the polarization cells have received a sufficient charge by a short charging shock and thereby acquired an electro-motive counter force, the battery current becomes zero, so that no weakening of the battery through a continuous current takes place (as is the case in noninductive ohm resistances connected parallel to the spark gap).

When the circuit of the relay tongue is closed the current is conducted through the winding of the tapper, the resistance of which is about 6 ohms, and the polarization cells, thus short circuited by the relay, are discharged simultaneously. Upon the opening of the tongue the polarization cells admit the amount of electricity produced by the opening of the current through the self-induction of the tapper and Morse magnets, so that there no longer appears at D_2 an opening spark which might excite the coherer.

The Morse apparatus lies parallel to the tapper. It has four connecting posts which are connected parallel in pairs and one pair of which can be switched out. By connecting the red strand to the posts which can not be switched out the Morse magnets are connected parallel to the tapper magnets.

From the two connecting posts of the Morse recorder, which are adapted to be switched out, an alarm branches off which is to be connected only when no one is in the apparatus room. The opening spark of the alarm interrupter is also obviated by polarization cells, placed into the wooden board of the alarm.

B.—APPARATUS OF TYPE 2.

(A) TRANSMITTER

The special induction coil with spark gap and Morse key used for this apparatus gives at a secondary load of a capacity of 0.0002 microfarad a spark 3 to 5 millimeters in length (fig. 20).

Dry cells are used as source of current.

The transmitting wire is an ordinary uncovered wire, held in the air by means of small kites or balloons.

(B) MICROPHONE RECEIVER WITH RECEIVING TELEPHONE.

As a receiver a tunable microphone receiver with receiving telephone is used.

Starting from the fact that microphones, different from coherers, are not actuated by voltages, but by current intensities, the Slaby-Arco people have arranged their system of circuiting for microphone receivers in such manner that the microphone is located in an artificially increased potential loop of the receiving wave circuit (fig. 19). As the microphone, moreover, has not been placed directly into the receiving system, but into a branch of the same, they claim to have succeeded by their system of circuiting (the same as in their system with coherers as indicators), on the one hand, in precluding entirely atmospheric disturbances, and on the other hand, in attaining pure tuning and thus increasing the receiving intensity.

The dry cell F, which, through the double-pole switch Q is connected in series to the grain or spring microphone M and the receiving telephone T through the choking coil D, is contained in a wooden box. By the closing and opening of a contact button K the microphone is raised to an initial resistance of about 150 ohms, so that a weak, continuous current corresponding to the resistance of M passes through the telephone.

When the distance effects received by the transmitting wire S strike the microphone at A, its resistance varies within narrow limits and causes alternations of potential of the local battery F. At each spark of the transmitter a noise is heard in T.

The primary frequency of the transmitter should be at least high enough to cause 100 sparks to jump over, because tones of a less number of vibrations than 100 a second are more difficult to hear through the telephone.

The tuning of such a microphone receiver is effected by connecting it to the receiving wire S, which is tuned to the oscillations of the transmitter through the tuning coil S_1 close above the earthing point at B in a branch circuit, which latter is tuned to the oscillations of the transmitter by the self-induction S and the condenser C, adapted to be regulated by crank and earthed at E.

The sensitiveness of the microphone receiver is greater than that of a sensitive coherer, so that with the use of the microphone the maximum signaling distance is considerably longer than with the use of the coherer. But owing to the very variable resistance of the microphone it is impossible to record, by means of a relay and Morse recorder, the changes of resistance produced in the microphone by the electric distance effects, so that no written signals can be obtained with the microphone nor can the station be called up.

POPOFF-DUCRETET RECEIVING STATIONS.

Fig. 1 is a total view of the organs of the receiver. They are inclosed in an easily portable metal box. Fig. 2 is a diagram of the connections (E. Ducretet establishments).

The Branly coherer and A. Popoff automatic tapper are the principal parts characteristic of this Popoff-Ducretet receiver. The coherer Br is fitted with a device adapted for the transmission and reception of electric waves at long distances. Figs. 3 and 4 show this Ducretet coherer. It is air-tight, adjustable, and can be taken apart. The metal filings at L are protected from dampness and renewal of the air. The practical advantages of this device are of the utmost importance,

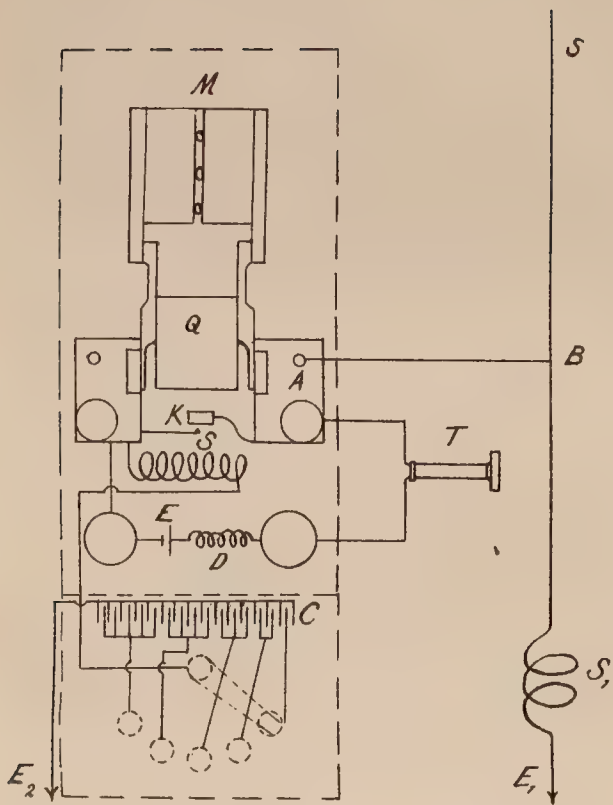


FIG. 19.

SLABY-ARCO FIELD SYSTEM.

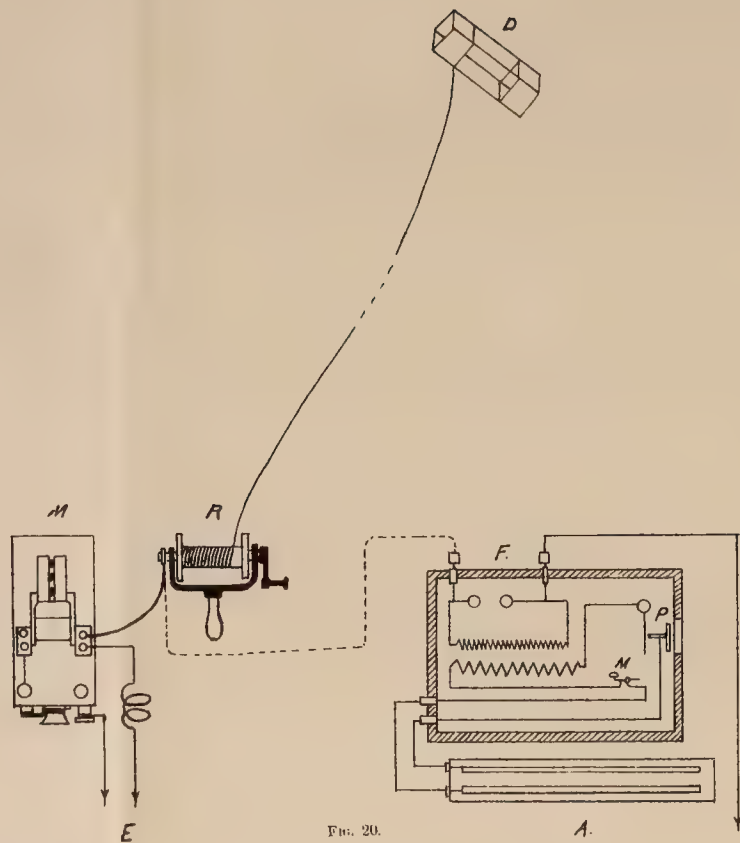


FIG. 20.

A.

as they permit very good coherers to be obtained in a few minutes, in all kinds of weather and places. These coherers can be brought quickly to the required degree of sensitiveness.

Fig. 5 shows an adjustable Ducretet tube of great sensitiveness. It does not have electrode plugs soldered into the glass, but electrodes of parallel and neighboring wires soldered into the glass at *a b*. This coherer possesses great advantages; but as its adjustment is effected by reversing from R to R', and vice versa, the coherer shown in figs. 3 and 4 is more practical.

We have employed several types of automatic tappers; some of them break automatically the circuit of the coherer; others apply the principle of automatic short-circuiting. These devices furnish good results. When well adjusted, the one shown at E F, fig. 2, works perfectly.

Fig. 1 shows at R the Siemens polarized relay which has been successfully used by different electricians in their experiments. This relay when well regulated has no superior as to sensitiveness; but it must be conceded that its adjustment is delicate, and when not made properly this Siemens relay loses all its sensitive qualities.

At the very beginning of Hertzian wireless telegraphy we indicated, in our French patent of November, 1897, and in our notice of 1898, our preference for relays with movable frame as giving good results and offering advantages for use in connection with wireless telegraphy. In this direction we have made several very important improvements in the movable-frame relay designed by Siemens in 1884 and successfully used since 1885 in France as well as in England in submarine cables.

The diagram in fig. 6 shows a relay of the Ducretet type. The arrangement and the means of adjustment characteristic of this relay insure to it greater sensitiveness, quick and easy adjustment, and great steadiness while in operation.

The auxiliary resistances required for the perfect operation of the relay R (fig. 2) have been mentioned by different authors (Culley in 1882) and by ourselves. The resistances R_e , R_e' , R_e'' , fig. 2, answer this purpose. Additional resistances, referred to by Mr. A. Popoff in 1895, may be put in the circuit of the receiver.

The battery P of the coherer (fig. 2) should be of small voltage. The battery specially designed by us for wireless telegraphy is of small E. M. F. ($E = 0.25$ volt). This battery P, as well as the battery P' of the tapper and Morse receiver, are located in the compartment at the rear of the box of the receiver (fig. 1).

Fig. 7 is a telephone receiver of the Ducretet-Popoff type ("Comptes Rendus de l'Académie des Sciences," December, 1900). The lattice of fine wire (or the hard steel particles several times oxidized) placed at Br constitutes alone the sensitive receiving organ of this apparatus.

The circuit comprises a battery (placed in the compartment at the rear of the portable box), the two telephones T T', and the special coherer Br; an interrupter I opens and closes this circuit. The collecting wire is placed at L and the earth connection at Te, the same as above (fig. 2).

This apparatus does not require any relay nor an automatic decoherer (Popoff tapper); as soon as an electric wave has struck the coherer the latter returns to its original state of resistance, and the changes of resistance are perceptible directly in the telephones. The reading is done by sound.

The E. Ducretet automatic Morse receiver (fig. 8) is adapted to receive the signals without the assistance of a telegraph operator. All by itself this automatic recorder unrolls its paper fillet as soon as a signal arrives and stops of itself as soon as the signals cease to appear at the receiving station (figs. 1 and 2). Blank spaces separate from each other the telegrams received and recorded on the strip of paper.

In a thunder storm this receiver is able to record automatically the atmospheric discharges ("Comptes Rendus de l'Académie des Sciences," June 13, 1898) even when far off. In the majority of cases we have been able to ascertain that such intermittent atmospheric discharges did not render illegible the Hertzian telegrams received simultaneously.

The Ducretet automatic recorder for Hertzian wireless telegraphy and for ordinary electric telegraphy can, in certain cases, insure the privacy of the messages received; the person for whom they are intended can take off the messages so recorded one after another as they are sent without needing the presence of an operator. (Bulletin de la Société d'Encouragement," December, 1898.)

The automatic release of this apparatus is at A R, and is controlled by the relay lever R'. (See Guide and special instructions.)

TRANSMITTING STATIONS.

Fig. 17 shows a complete transmitting station. It comprises:

Bo=Ruhmkorff induction coil.

I=Periodical interrupter.

M=Operating key.

O=Hertz radiating oscillator with two balls (fig. 19).

The Ruhmkorff coil Bo is a transformer of electric energy. Our Ruhmkorff coils can be easily transported and are equal to any as to energy and durability. The earthing of one of the poles offers no difficulty (figs. 9 and 10).

Fig. 10 is a complete diagram of the transmitting apparatus; fig. 11, of a Hertz radiating oscillator of the Popoff-Ducretet type. In figs. 9 and 10 the latter is shown at O.

The earth connection Ca' and the connection to the insulated conductor Ca of the Hertz oscillator (Tesla, 1893) perform the functions of electric capacities, rendering the sparks jumping at X oscillating. These discharges set up electric oscillations which are propagated through Ca (fig. 10) and then into space. The upper part of Ca (the radiating conductor) appears to be the most effective for this propagation of electric waves through space.

In the primary circuit of the Ruhmkorff coil Bo are the periodical interrupter I and the operating key M (fig. 9), according to the diagram of fig. 10.

By means of the operating key M, for strong currents (E. Ducretet type), there are produced in the secondary circuit of the induction coil Bo intermittent discharges of long or short duration, and consequently a series of oscillating sparks at X, fig. 11, of the same duration. They launch into space long and short Hertzian signals, which, in different combinations, constitute the conventional language known as the Morse signal code. These Hertzian signals or electric waves are received by the collecting wire Ca, which is carried to the coherer of the receiving station (figs. 1, 2, and 7).

N. B.—When using double stations, the conductor Ca (fig. 10) is the collecting or the radiating wire, according as the station receives or transmits.

The periodical interrupter, indicated at I and at M (figs. 9 and 10), has an electric motor and intermittent contacts in the mercury.

The periodical interrupter shown in fig. 12 has solid contacts, copper on copper, in an insulating fluid. It operates directly, without any auxiliary current, in the same circuit as induction coil Bo (fig. 12).

2. CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY APPLIED TO WIRELESS TELEGRAPHY—SYNTONY OF STATIONS—SIMULTANEOUS RECEPTION.

As we were the first in France to construct apparatus after the E. Thomson and N. Tesla principle (currents of high potential and high frequency), and also apparatus for wireless telegraphy, it was but natural that we should apply these currents, of whose inductive power we were aware, to wireless telegraphy, since we had at our laboratory the apparatus devised for the generation of such currents.

Our patents in 1897 and our special notices in 1898 and 1900, as well as our legal applications for patents, indicate clearly the employment of these currents in wireless telegraphy (anticipated by Tesla as early as 1893).

After a long series of experiments between our experimental stations, we have set forth the practical importance of the results arrived at by us with currents of high potential and high frequency applied to wireless telegraphy. The following statements will make it appar-

ent that these currents increase the range of the waves and facilitate their reception at great distances; that they render it possible to tune two stations to each other; that the aerial conductor can not assume a state of charge under the influence of atmospheric electricity, being in direct connection with the earth; that the aerial conductor while transmitting (radiating conductor) can be touched with impunity, the innocuity of the currents of high potential and high frequency having been positively demonstrated by Dr. d'Arsonval's physiological experiments.

As the capacity of the condensers of these apparatus can be varied within very wide limits, as also the self-induction of the circuits, it is possible to obtain the necessary resonance and waves of sufficient length to render the phenomenon of diffraction very perceptible and to permit the transmission of Hertzian waves to great distances notwithstanding the interposition of material obstacles, such as the curvature of the earth, hills, islands, etc.

The period of the electric oscillations set up in the transmitting circuit varies with the self-induction, the capacity, the height of the aerial conductor, and the length of the oscillating spark passing at X (figs. 10 and 11). The period T of the electric oscillations is

$$T = 2\pi\sqrt{LC}, \quad (\text{Thomson's formula.})$$

L and C being respectively the self-induction and the capacity of the circuit.

If the corresponding elements L' and C' of the receiving circuit can be varied in the same manner and the result T made to equal T' , resonance will have been effected between the transmitter and receiver and the stations made syntonous. From this point of view the experiments of Prof. O. Lodge are interesting and very lucid.

By the appliances devised by us to that end such resonance can be effected. They are adaptable both to the receiving and the transmitting apparatus which we have described. These appliances will be described in the near future in a special notice. These appliances render it possible to receive messages simultaneously on two different apparatus with the same aerial conductor and with transmitters emitting waves of very different wave lengths.

According to Maxwell, the propagation of the Hertzian undulations—that is to say, the alternating current of high frequency—takes place in the surface part of a conductor, while in the case of continuous currents the transmission takes place through the whole mass of the conductor. Following this order of ideas and the experiments of Branly in 1890 and of Popoff in 1895, Professor Slaby has demonstrated that it is possible to receive simultaneously, at a great distance, with one and the same aerial conductor, two telegrams, one by means of the Hertzian waves, the other by the ordinary method of electric telegraphy with batteries.

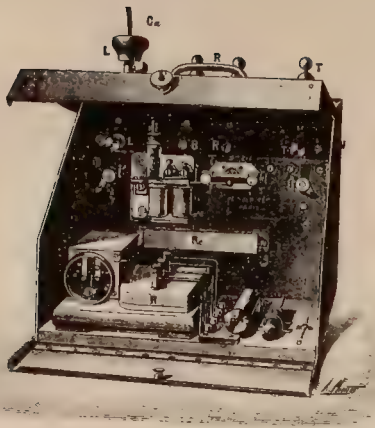


Fig. 1.

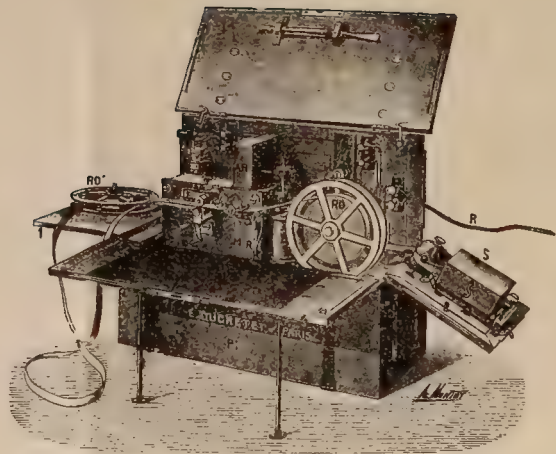


Fig. 8.

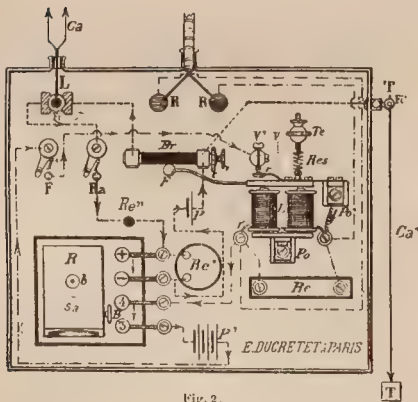


Fig. 2.

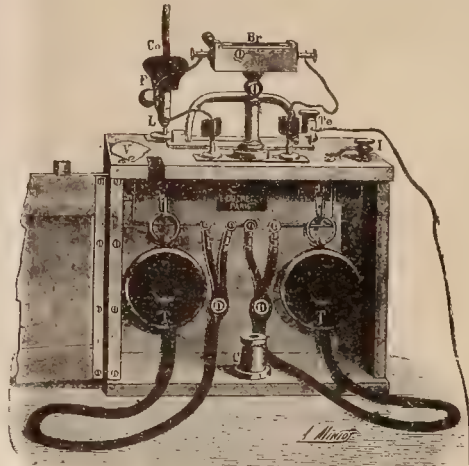


Fig. 7.

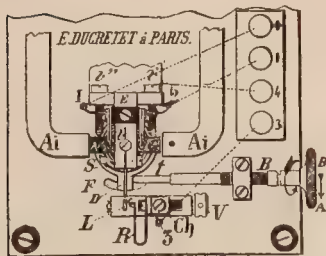


Fig. 6.

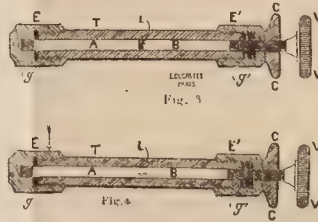


Fig. 3.

Fig. 4.

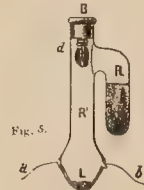
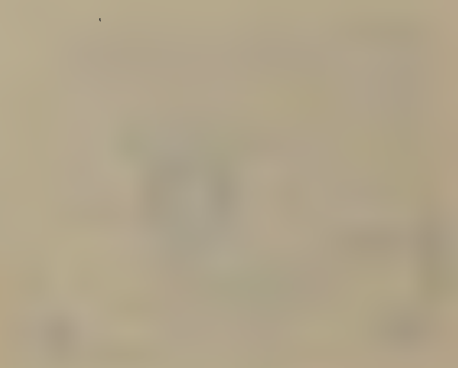
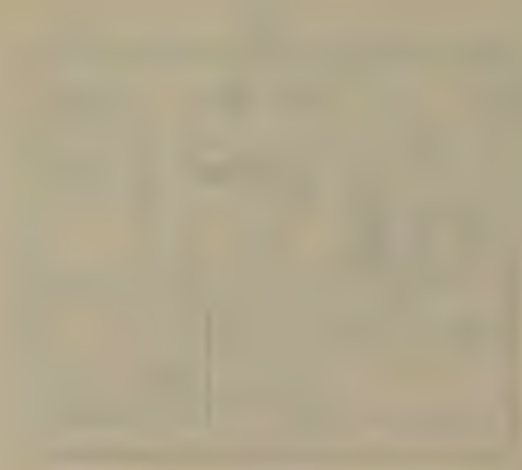
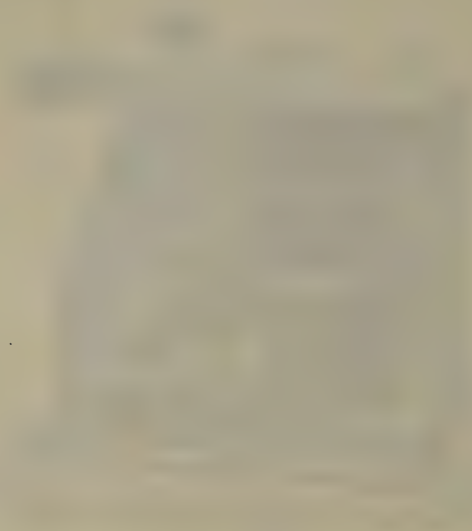


Fig. 5.



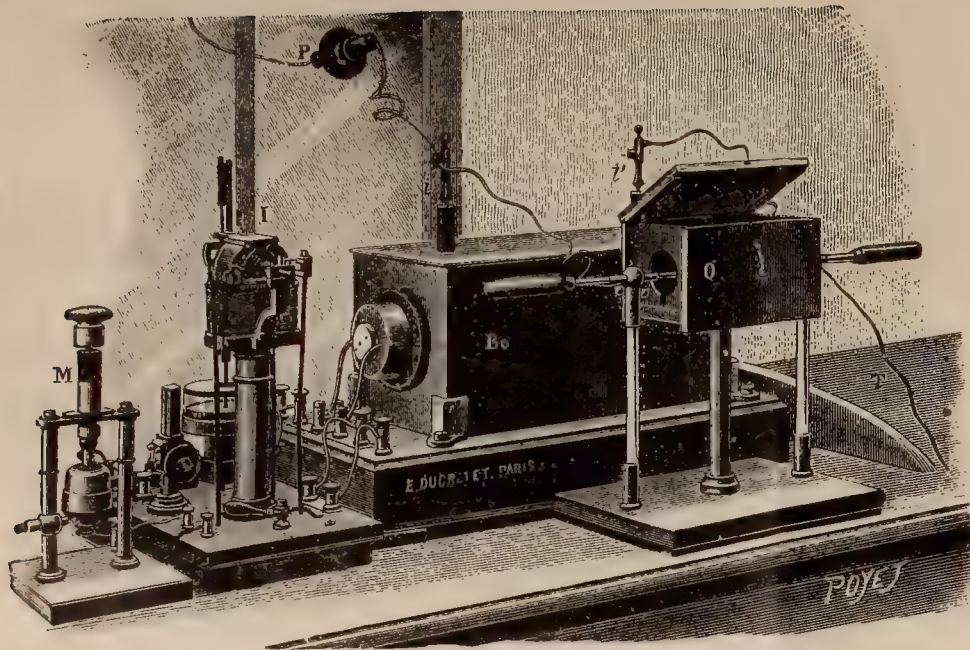


Fig. 9.

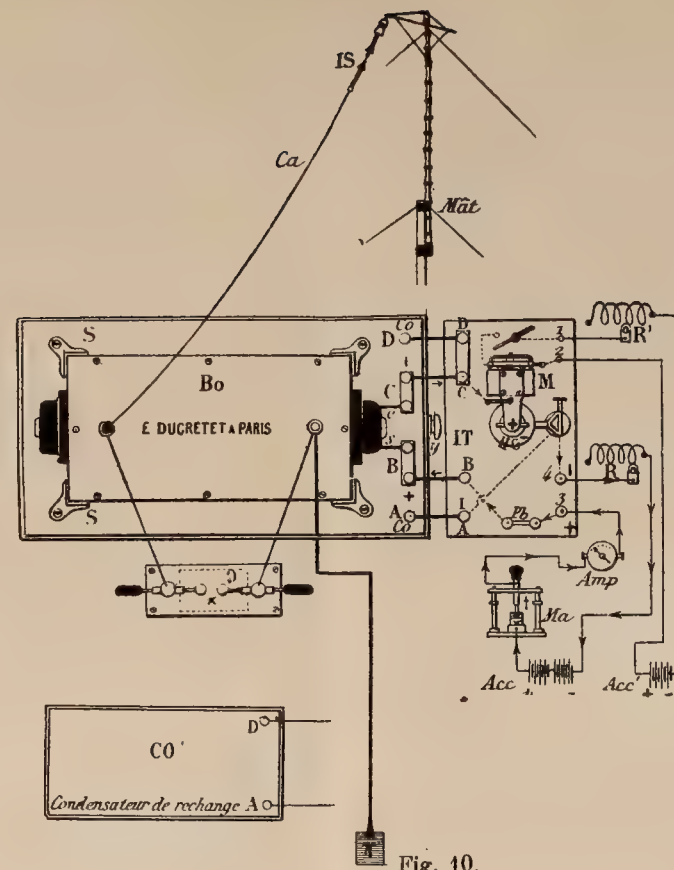


Fig. 10.

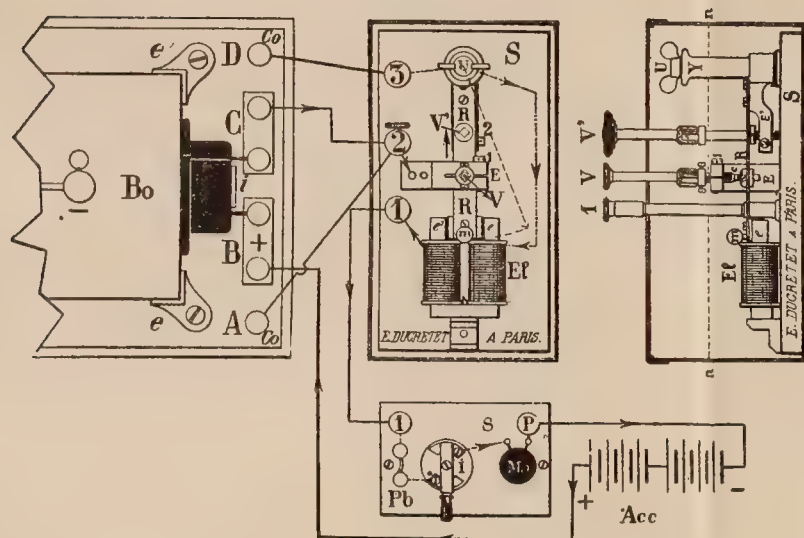


Fig. 12.

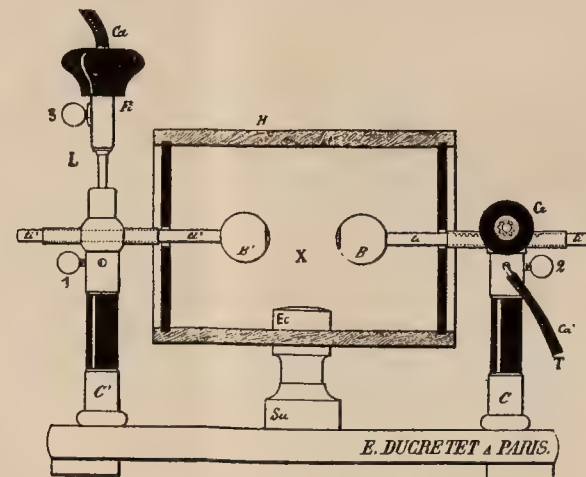
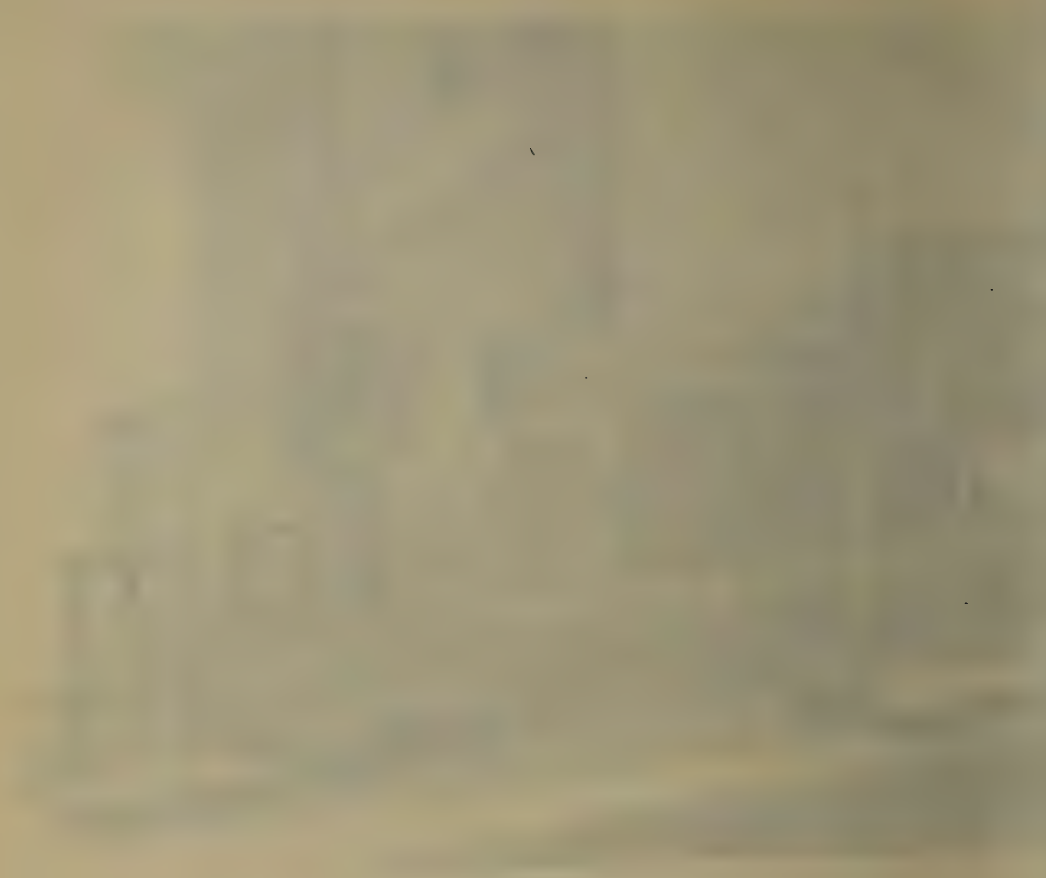


Fig. 11.



3. SOURCES OF ELECTRIC ENERGY.

The long-distance effects characteristic of Hertzian wireless telegraphy require receivers of only small electric energy. It is not so in the transmitters; to insure their perfect working they require great electric energy, supplied either by a battery of accumulators, a dynamo, or a galvanic battery of great power.

THE BRAUN (SIEMENS-HALSKE) SYSTEM.

[From *L'Éclairage Électrique*, February 1, 1902.]

The fundamental idea of Mr. Braun and of his wireless telegraphy arrangements is the use of condensers in greater or less quantity in the vibratory circuit.

The induction coil charges the condenser, and it is the discharge spark of the battery between the oscillator poles which produces the electric oscillation to be transmitted to the antenna.

In the first arrangements of Marconi and those of Slaby, at least in the earlier or simpler forms, the electric vibration is imparted to the antenna by very rapid oscillations of very short wave length. With condensers, on the contrary, the oscillations are much more rapid, corresponding to distinctly longer wave lengths.

It is in the utilization of great wave lengths instead of short ones that Mr. Braun claims to vary from other methods. According to Mr. Braun, the earlier Marconi system, having its oscillator directly joined to the antenna and to earth, presents the following disadvantages:

It is not possible to increase the useful effect by increasing the potential (i. e., lengthening the spark) above a fixed value, which is soon reached. The spark ceases then to be active. All additional energy is useless for transmission and seems to be wasted in heat effect in the spark.

It is impossible to obtain good capacity in the aerial conductor when it is open. The only possible way of increasing the effects at a distance is in lengthening the antenna, and practical considerations soon limit this.

The antenna is charged at a high potential. Besides the danger which this may cause, perfect insulation is necessary in order to prevent the discharge of the antenna at any moment and resulting gaps in the transmission.

The oscillations are badly deadened by the spark, which is injurious for resonance and the securing of syntony. As is well known, what we observe is only the particular vibration of the resonator, excited by the first impulses of emission. According to Braun, these defects are inherent in every installation in which sparks are produced with feeble capacities, and they may be eliminated to some extent if the transmitter is fed with great capacities after the arrangement to be described later, these arrangements requiring always the direct excitation of the antenna, the spark being in the circuit of the transmitting antenna.

Mr. Braun claims a superior method of excitation in which the oscillations are transmitted to the antenna by induction instead of directly, the antenna being prolonged at its base by the secondary of a special transformer whose primary receives the oscillations of the spark discharge.

Fig. 1 shows this arrangement.

Mr. Braun claims that this eliminates the above-mentioned disadvantages and presents the following improvements:

1. Very great quantities may be used in the primary circuit with useful effect. Increasing the primary energy increases the useful effect in much greater proportion than in the Marconi arrangement. In proof of this he gives the following table. It is not stated how the values are obtained, but probably by the limit range of transmission in each case.

Current in coil in amperes.	Relative electro-magnetic energy.	
	Marconi.	Braun.
2	8	26
2½-3	10	40
4	10	55
6	10	62

2. The oscillations of the antenna have, as has been proved by Tesla, very little physiological action. It is possible to touch the antenna or even to draw sparks from it without danger.

3. Less care in insulating the antenna is required. Oscillations in the primary are rarely influenced by defective insulation in the antenna, and the gaps noted above are impossible.

4. The oscillations of primary and secondary circuits are little deadened and may be regulated so as to increase considerably the vibratory amplitude of the antenna, owing to the resonance obtained in the two circuits, and thus we have good use of the primary energy. One of the circuits contains the condensers, the spark, the primary of the transformer; the other circuit, its antenna and the secondary of the transformer. The resonance between the circuits must be made as great as possible by arranging suitably the number and size of the condensers as well as the windings of the exciting transformers. When the proper electric dimensions are found for the different heights and sizes of antenna, they may be easily duplicated.

5. Finally, the vibrations of great wave length and but slightly deadened, which are set up in the antenna and transmitted into space, satisfy the fundamental requisites for obtaining a satisfactory electric accord between transmitter and receiver. The problem of syntony is thus a long step nearer to solution.

We may now show the various arrangements of Braun for using the discharge of condensers, directly or by induction.

1. DIRECT EXCITATION OF THE ANTENNA.

Fig. 2 represents one of these arrangements. If the induction coil S were not fixed at A, but at another point, for example, to take an

extreme case, at the upper end B, of the antenna, we have an arrangement described by Slaby. (See p. 325, No. XX, 1901, of these notes.)

Braun claims that his arrangement is entirely different in principle and superior theoretically and practically to the analogous one of Slaby. He agrees with Slaby, however, that the vibratory movement of the antenna might be influenced by the addition of capacities, alone or combined with induction coils which end the antenna B.

Fig. 2 shows no direct connection to earth of the vibratory circuit. A point of this circuit may also be connected to earth directly or by a spark. This is done in the arrangements shown in figs. 3 and 4. In every case even with direct excitation of the antenna, in order to have the best effect it is necessary to obtain resonance of the antenna itself and the vibratory circuit.

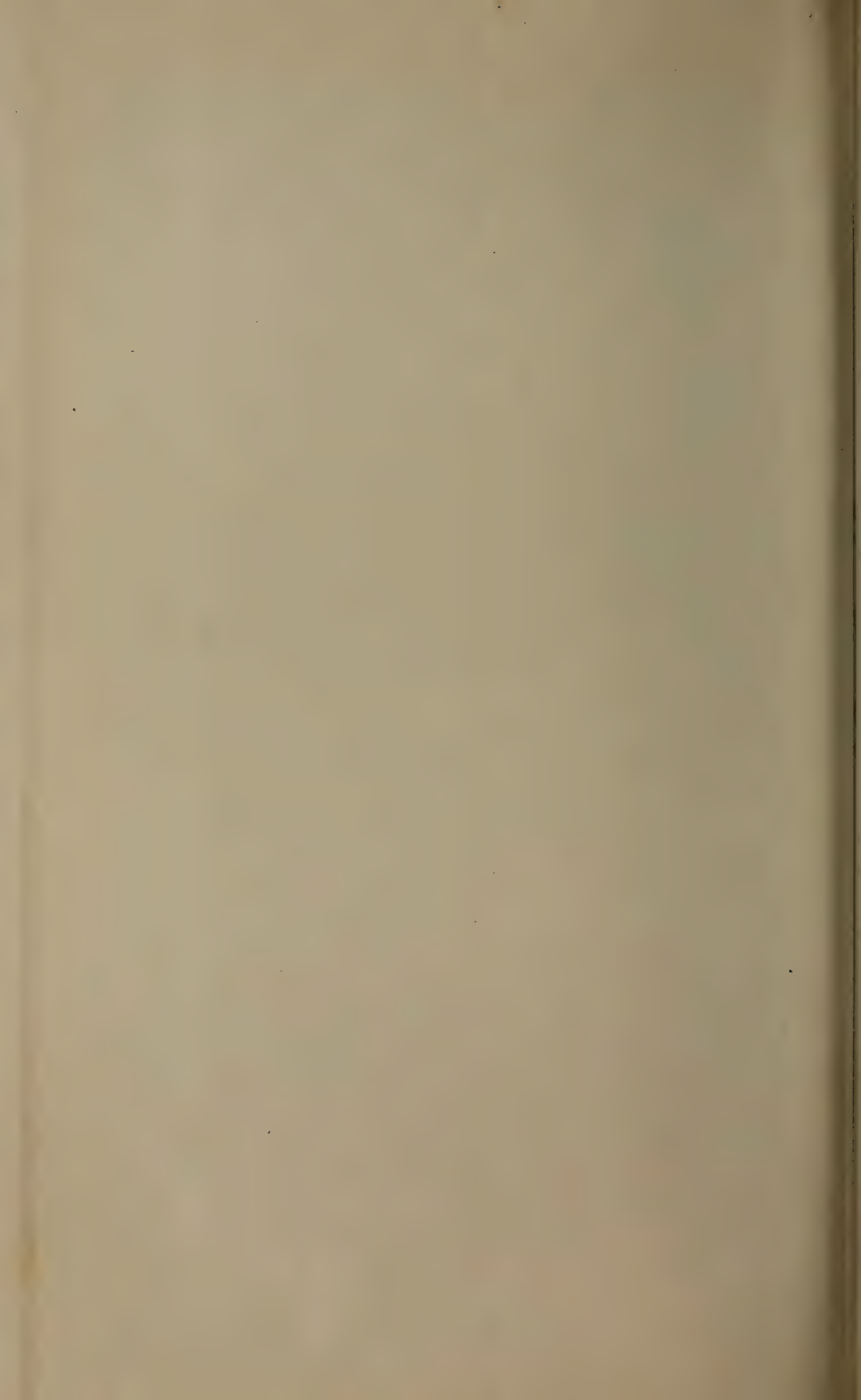
2. EXCITATION BY INDUCTION.

Usually one of the ends of the antenna is insulated completely from the earth. According to Braun, the transmitter coil in which the waves are generated need not necessarily be earthed. Also, instead of being at one end, it may be carried nearer to the middle and divide the transmitting circuit into two equal parts (fig. 5). Braun does not give indications as to the best relative positions of the two parts A B, C D.

The ends of the transmitter may be joined to earth by the intermediary M of a self-induction, a suitable capacity, a combination of both, by an ohmic resistance, or by a spark.

Fig. 6 represents a form used in practice. B is a spark joined to earth. It is at a maximum explosive distance. This spark can as well be placed at A. The arrangement of fig. 7 may also be employed, which in its turn may be modified or combined with many others. A point of the primary circuit may itself be joined to earth directly or indirectly. There are a number of modifications given by Braun to his arrangements.

In all cases they depend in principle upon the use of condensers and for the greater part upon the excitation of the antenna by induction. In every case an effort is made to arrange the dimensions of the circuit so as best to satisfy the conditions of resonance.



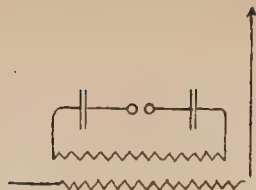


Fig. 1.

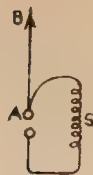


Fig. 2.

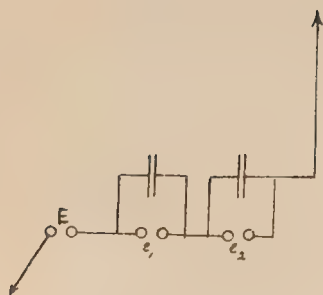


Fig. 3.

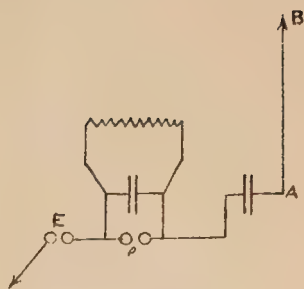


Fig. 4.

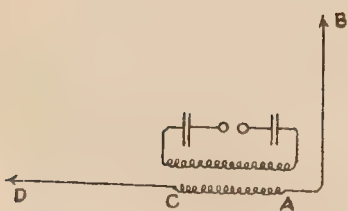
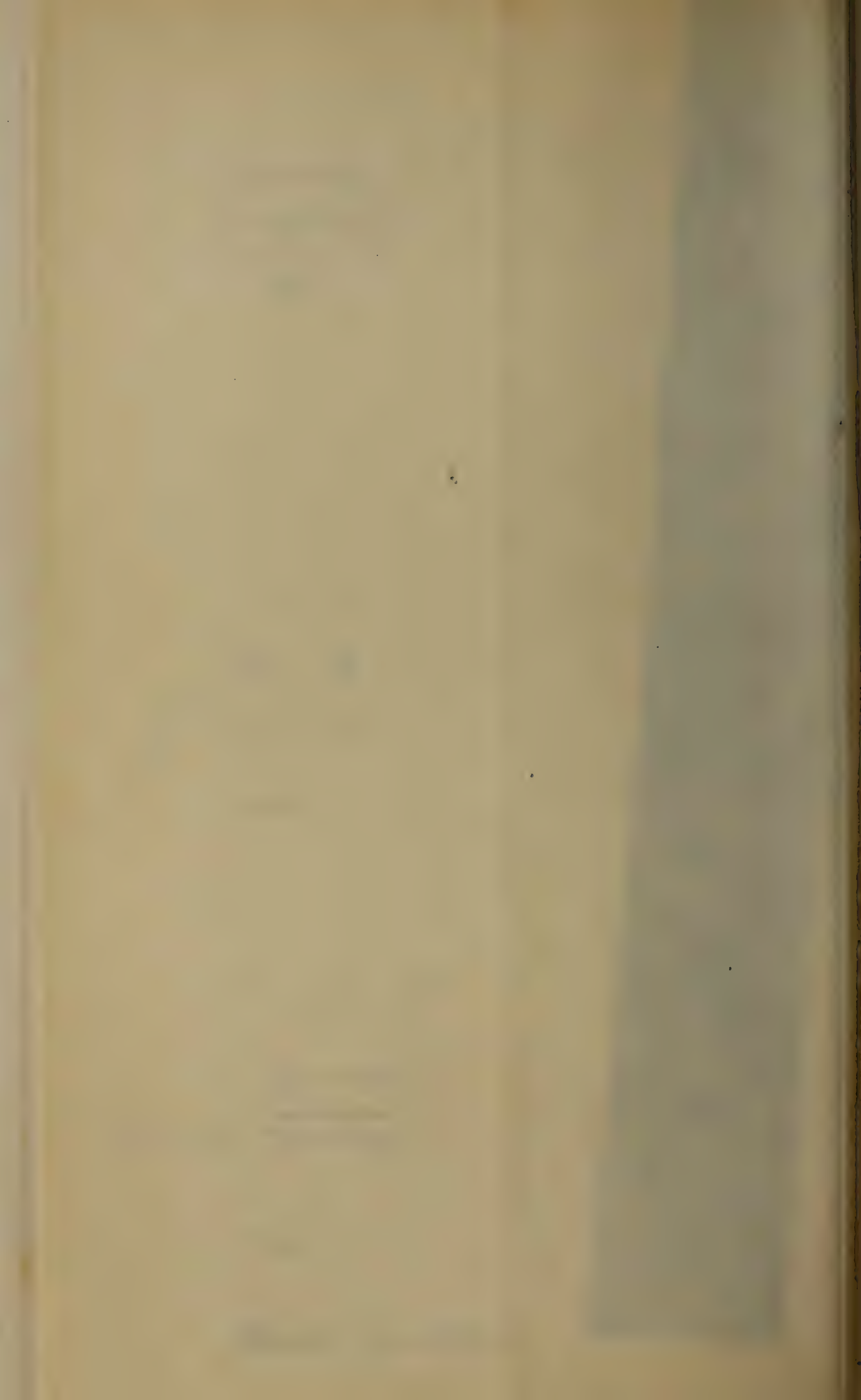


Fig. 5.



Fig. 6.

Braun System Wireless Telegraphy



VI.

NAVAL MANEUVERS OF 1901.

By Lieutenant LOUIS M. NULTON, United States Navy,
Staff Intelligence Officer.

SECTION I.

ENGLAND.

These maneuvers were on a larger scale than ever before attempted, no less than 163 ships, large and small, participating.

The Channel Squadron, known as X Fleet, consisting of modern ships representing an enemy, with Ireland, the Channel, and Scilly Isles as bases, was pitted against the Reserve Squadron, styled the B Fleet, the latter comprising less modern but more numerous vessels.

Each fleet had the services of torpedo flotillas and cruisers, in all 111 torpedo boats and destroyers taking part.

As expressed in the order of the Admiralty, "Each fleet is to try to obtain command of the English Channel and of the approaches to it and to St. Georges Channel, X's ultimate aim being to stop trade in those waters and B's to cover it."

For several weeks vessels were preparing at the various dockyards, but no official announcement was made until July 11, when the official programme was given to the press by the Admiralty. On the same day the Admiralty chartered 21 steamers on the freight market for the purpose of taking coal from Cardiff, Barry, Penarth, and Newport to the fleets during the maneuvers. The capacity of these steamers averaged about 1,500 tons each, and they were chartered at the rate of 10s. 6d. per ton gross registered tonnage. They were to be ready to load from July 17th to the 22d. Fifty thousand tons of coal were purchased by the Admiralty.

Permission was not granted to naval attachés to witness the maneuvers, but a limited number of newspaper correspondents were allowed on board certain vessels of the fleet, and it was expected that valuable information would be obtained from their reports. On the second day of the maneuvers, orders were issued requiring all reports

to be submitted, and the censor's pencil struck out nearly everything of interest."

The naval maneuvers of 1901 were the most realistic of the series of some 13 or 14 that have been held since their first inception during the eighties of the last century. This result is largely due to the absence of artificial rules. To get rid of these rules has been one of the objects of naval reformers for some years past. In the maneuvers of 1901 it was laid down for the first time that the umpires were to judge each case on its merits on the basis of what would be probable in war. It was not only in the rules which apply to the tactical aspect of maneuvers that the framers of the scheme had shown a wise foresight. The rules which were discarded applied to the tactical aspects of war or to the shock of actual battle, while the object of the maneuvers is strategical and applies to the whole theater of war. If the object is set forth without strategical insight the maneuvers can be ruined as certainly as by defective rules. All strategy should recognize that the objective in naval war is the mobile force of the enemy, and that the way to defeat the enemy is to concentrate in superior numbers on any portion of his force so as to defeat him in detail. Hence we can formulate a general principle of concentration which recognizes that an attempt to attack territory and trade lessen the effective concentration on the enemy's mobile force, and so are bad strategy unless they can force the enemy to indulge in an even greater dispersion of his own war ships.

So far did the framers of the maneuvers go in the recognition of this great principle that they laid down the object to be what historically has always been the objective of naval war, viz, the attainment of the command of the sea, with the ultimate object of destroying the enemy's trade. Thus stated in the original programme, the maneuvers promised to afford a tactical and strategical exercise superior to any yet had. The performance bore out the promise.

OFFICIAL PROGRAMME.

The following official documents were issued, from the Admiralty, with reference to the 1901 maneuvers:

GENERAL IDEA.

The maneuver area lies between the fifty-sixth and forty-seventh parallels (see Chart 1).

Fleet B is cruising in the North Sea, and can coal at Plymouth, Portland, or Portsmouth. It has detachments of cruisers and torpedo craft at Plymouth, Portland, and Portsmouth.

"Since the preparation of this account, a report of the maneuvers was issued by the Admiralty as a return to an order from the House of Commons. The report, the charts excepted, amounted to little more than an elaboration of the "narrative of the umpires" as published soon after the close of the maneuvers. The charts have been inserted and portions of the last-named narrative.

Fleet X is cruising off the north coast of Ireland, and can only coal at Queenstown or the Scilly Islands. It has detachments of cruisers and torpedo craft at the Scilly Islands and the Channel Islands which can coal at those places.

The whole of Great Britain below the fifty-sixth parallel belongs to B.

The whole of Ireland, together with the Scilly Islands and Channel Islands, belongs to X.

The orders from the Admiralty to commence hostilities do not necessarily reach both sides at the same time.

The following forts are fortified and are placed in a state of defense: In Great Britain, Portsmouth, Portland, Plymouth; in Ireland, Queenstown.

All other ports are unfortified, except the Scillies, Alderney, and Guernsey, which, together with the vessels in those ports, are to be considered proof against attack by vessels of any description.

The examination service is to be brought into operation at Portsmouth, Portland, Plymouth, and Queenstown, but is only to be made applicable to ships of war; merchant ships are not to be interfered with.

Each fleet is to try to obtain the command of the English Channel and of the approaches both to it and to the St. George's Channel, X's ultimate aim being to stop the trade in those waters, and B's to cover it.

RULES AND REGULATIONS TO BE OBSERVED DURING THE 1901 MANEUVERS.

No rules setting forth the conditions under which ships will be put out of action will be issued. Each case must be decided by the umpires on its merits on the basis of what would be probable in war.

When two or more ships come into action the commencement of the engagement is to be marked by the firing of a gun by one of the ships engaged. During the engagement single guns are to be fired at about one minute intervals by the ships engaged.

When either side considers that he has beaten the other, he should signal "Propose reference to umpires." If the other agrees to the reference the action is to cease. If the other does not agree the action may continue, but not for more than a reasonable time, which is to be determined by the senior officer present. A reasonable time under ordinary conditions would be one hour in the case of battleships, cruisers, and torpedo gunboats, and half an hour in that of destroyers and torpedo boats.

When reference to the umpires has been settled, the senior officer present is to determine what ships on either side are to proceed into port to await their decision, pending which the ships detached are to be considered out of action. The senior officer present must take care to select as far as possible equally from both sides.

If a ship is undoubtedly torpedoed, or manifestly overpowered by a much superior force, the senior officer present may take the responsibility of temporarily putting such ship out of action and ordering her into port for the decision of the umpires. In this case it will not be obligatory to order into port a ship from the opposite side.

Ships put out of action can take no further part in the maneuvers, but must return to one of their base ports—Queenstown, Scilly, Alderney, Guernsey, Plymouth, Portland, Portsmouth—flying the Blue Peter at the fore. They are to select a route as far as possible clear of the scene of operation, and are strictly enjoined not to communicate any information to the ships on either side which they may meet on the way.

Colliers are not to attack at sea.

Signal stations are not open to attack by landing parties.

As the 18-inch torpedo can not be fired at a ship in a peace exercise, a destroyer is to fire a blue light by night or blow her whistle by day at the moment when the torpedo would be discharged, the tube being trained and all adjustments made as if actually firing.

Torpedoes fitted with collapsible heads may be fired at battleships and cruisers, but not at torpedo gunboats, destroyers, or torpedo boats.

Torpedo boats are not to paint out their numbers.

Care should be taken not to expose vessels needlessly to fire from forts.

The limits of those ports which are considered proof against attack are as follows: Alderney, a line drawn from the submerged end of the breakwater to the northern extreme of Chateau à l'Etoc; Scilly Islands, a line drawn from Menewetham through Newfoundland Rocks, Horse Point, Annet Head, Castle Bryer, Crow Point, Guthers Island, to Menewetham; Guernsey, a line drawn from Jerbourg Point to the southern extreme of Serk, and another line drawn from the northern extreme of Serk to the northern point of Herm and thence to Doyle Point.

During the operations ships are not to pass the limits of the maneuver area, and are not to enter foreign territorial waters.

In general terms, the subdivisions of the two fleets, as referred to in the narrative of the umpires, were as follows:

X Fleet.	{	X Main Fleet.	{	X Main Battle Fleet, or X Battle Fleet.
		Y Squadron.		X Main Cruiser Squadron.
		Z Squadron.		
B Fleet.	{	B Main Fleet.	{	B Main Battle Fleet, or B Battle Fleet.
		C Squadron.		B Main Cruiser Squadron.
		D Squadron.		

The elements of the two fleets are given in the table immediately following:

List of vessels taking part in the maneuvers.

[See end of chapter for details of ships.]

FLEET X.	FLEET B.
MAIN FLEET.	MAIN FLEET.
Majestic.	<i>Revenge.</i>
Magnificent.	<i>Sans Pareil.</i>
Prince George.	<i>Howe.</i>
Jupiter.	<i>Nile.</i>
Hannibal.	<i>Trafalgar.</i>
Mars.	<i>Benbow.</i>
Resolution.	<i>Anson.</i>
Repulse.	<i>Camperdown.</i>
Diadem.	<i>Collingwood.</i>
Niobe.	<i>Colossus.</i>
Hawke.	<i>Edinburgh.</i>
Immortalité.	<i>Dreadnought.</i>
Narcissus.	<i>Amphitrite.</i>
Furious.	<i>Ariadne.</i>
Arrogant.	<i>Edgar.</i>
Mersey.	<i>Galatea.</i>
Rainbow.	<i>Impérieuse.</i>
Retribution.	<i>Minerva.</i>
Pelorus.	<i>Hyacinth.</i>
Pactolus.	<i>Forth.</i>
Gleaner.	<i>Andromache.</i>
	<i>Apollo.</i>
	<i>Pandora.</i>
	<i>For.</i>
	<i>Latona.</i>
	<i>Onyx.</i>



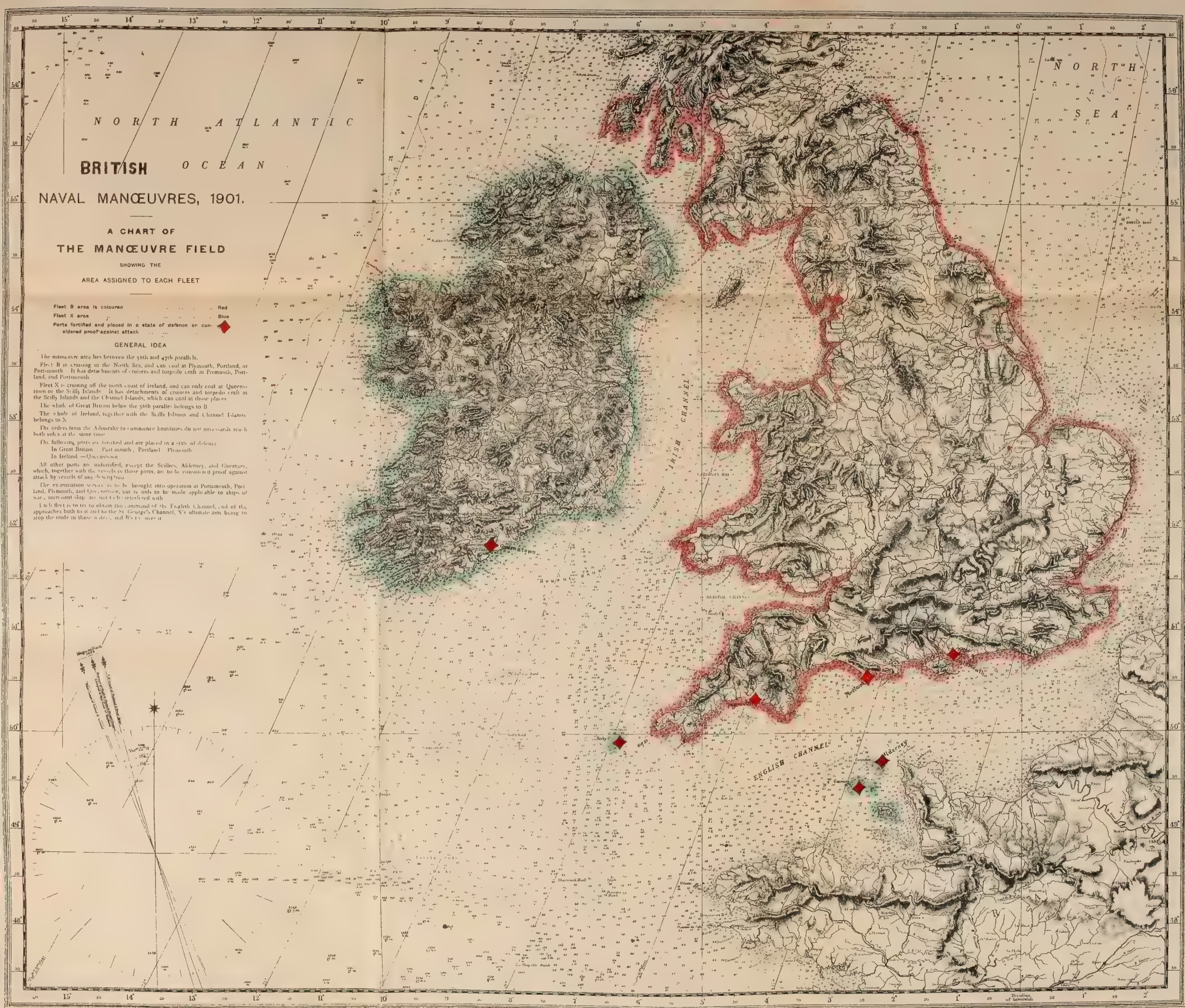
Scilly Isles.

++++ Limits of Protected Road

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NAVAL MANŒUVRES, 1901.

A CHART OF THE MANŒUVRE FIELD

SHOWING THE
AREA ASSIGNED TO EACH FLEET

Fleet B area is coloured Red
Fleet X area Blue
Ports fortified and placed in a state of defence or considered proof against attack

GENERAL IDEA

The manœuvre area lies between the 50th and 47th parallels.
Fleet B is cruising in the North Sea, and can coal at Plymouth, Portland, or Portsmouth. It has detachments of cruisers and torpedo craft at Plymouth, Portland, and Portsmouth.
Fleet X is cruising off the north coast of Ireland, and can only coal at Queenstown or the Scilly Islands. It has detachments of cruisers and torpedo craft at the Scilly Islands and the Channel Islands, which can coal at those places.
The whole of Great Britain below the 50th parallel belongs to B.
The whole of Ireland, together with the Scilly Islands and Channel Islands belongs to X.
The orders from the Admiralty to commence hostilities do not necessarily reach both sides at the same time.
The following ports are fortified and are placed in a state of defence:
In Great Britain — Portsmouth, Portland, Plymouth.
In Ireland — Queenstown.
All other ports are unfortified, except the Scillies, Alderney, and Guernsey, which, together with the vessels in those ports, are to be considered proof against attack by vessels of any description.
The examination service is to be brought into operation at Portsmouth, Portland, Plymouth, and Queenstown, but is only to be made applicable to ships of war, merchant ships are not to be interfered with.
Each fleet is to try to obtain the command of the English Channel, not of the approaches both to it and to the St. George's Channel, X's ultimate aim being to stop the trade in those waters, and B's to over it.

*List of vessels taking part in the manœuvres—Continued.***FLEET X**—Continued.**FLEET B**—Continued.**MAIN FLEET**—Continued.**MAIN FLEET**—Continued.**DESTROYERS** (from Devonport).**DESTROYERS** (from Portsmouth).

Leven, Locust, Thorn, Vigilant, Leopard, Gipsy, Tiger, Osprey.

Peterel, Kestrel, Chamois, Kangaroo, Crane, Vulture, Fawn, Myrmidon.

SQUADRON Y.**SQUADRON C.**

(Base, Scilly Islands.)

(Base, Plymouth.)

Brilliant.

Spartan.

Æolus.

Sirius.

Sharpshooter.

Skipjack.

Jason.

Renard.

Hecia.

DESTROYERS (from Chatham).**DESTROYERS** (from Devonport).

Lee, Cynthia, Sturgeon, Cheerful, Desperate, Angler, Salmon, Mallard.

Bat, Fairy, Shark, Opossum, Wolf, Panther, Fervent, Hasty, Zephyr.

TORPEDO BOATS.

Nos. 58, 66, 76, 98.

SQUADRON Z.**SQUADRON D.**

(Base, Channel Islands.)

(Base, Portland and Portsmouth).

Thames.

Melampus.

Iris.

Mercury.

Iphigenia.

Prometheus.

Intrepid.

Severn.

Seagull.

Scylla.

Sheldrake.

Leda.

Speedwell.

DESTROYERS (from Chatham).**DESTROYERS** (from Portsmouth).

Mermaid, Zebra, Avon, Bittern, Spitfire, Albatross, Snapper, Haughty, Porcupine, Ariel, Contest, Dasher.

Spiteful, Starfish, Viper, Harlock, Brazen, Dove, Wizard, Violet, Electra, Teazer, Sarty, Sylvia, Hunter, Charger, Bullfinch.

TORPEDO BOATS.

Nos. 55, 79, 81, 82, 85, 86.

*List of vessels taking part in the maneuvers—Continued.*FLEET **X**—Continued.FLEET **B**—Continued.SQUADRON **Z**—Continued.SQUADRON **D**—Continued.

UNDER REAR-ADMIRAL, QUEENSTOWN.

UNDER COMMANDER IN CHIEF, PLYMOUTH.

Curlew.

(For Plymouth.)

Seahorse.^a*Antelope.*Stormcock.^a*Traveller.^a**Tay.^a*

TORPEDO BOATS.

Nos. 45, 52, 53, 54.

UNDER COMMANDER IN CHIEF, PORTSMOUTH.

(For Portland.)

*Spanker.^a**Spey.^a*

TORPEDO BOATS.

Nos. 26, 27.

(For Portsmouth.)

*Circe.**Magnet.^a**Raven.^a**Landrail.^a**Trent.^a*

TORPEDO BOATS.

Nos. 41, 42, 49, 50.

ADMIRALTY INSTRUCTIONS RELATIVE TO UMPIRING.

The umpires will meet at the Admiralty, Whitehall, where all claims and statements for their consideration should be sent, addressed to the "Secretary of the Umpires."

In all cases of fire being opened, whether by forts or ships, on hostile or friendly vessels, telegraphic reports are to be sent by both sides as soon as possible after an engagement has taken place, and should give the following particulars:

1. Name of ship reporting.
2. Place.
3. Date and G. M. T.
4. Names or descriptions of vessels engaged.
5. Range.
6. Time under fire.
7. State of sea and weather.
8. Formation and relative position of the opposing forces engaged.

These telegraphic reports are to be followed as soon as possible by written ones. These should be accompanied by extracts from the ship's log or signal log, by track

^a For examination service.

charts when necessary, or by other documentary evidence likely to assist the umpires in arriving at a decision.

The decisions of the umpires are final.

No reference will be made by them to the Admiralty before arriving at a decision.

The decisions of the umpires will be communicated to the Admiralty as soon as possible after they have been arrived at, in order that, if desirable, they may be made known to the senior officer on each side.

Should the Admiralty desire to communicate with the fleets during the progress of "hostilities," and their instructions be conveyed by a ship attached to either of the opposing forces, or by any other ship, such a ship is to display the signal "A K H."

It will thus be known that she is acting under Admiralty orders, or is about to deliver dispatches or telegrams, or to signal orders received from the Admiralty, and the respective admirals and senior officers are to take the necessary steps to insure that the orders so communicated are forwarded and acted on without delay.

If the commanding officer of one vessel sights another flying the signal "A K H" he is at once to close her, so as to place himself at a convenient distance for communicating by signal, should it be necessary.

GENERAL ORDERS AND INSTRUCTIONS.

The vessels specially commissioned for the maneuvers will be attached to the Coast-Guard and Channel squadrons. They will assemble as soon as ready at Portland and Torbay, respectively, and will be formed into two fleets, to be known as Fleet B and Fleet X, respectively.

Four special squadrons, composed of cruisers, torpedo gunboats, and torpedo craft, will be formed. Two of these, known as Squadrons C and D, will be attached to Fleet B, and will assemble at Portland. The other two, known as Squadrons Y and Z, will be attached to Fleet X, and will assemble at Torbay.

The bases of these special squadrons during hostilities will be:

Squadron C	Plymouth.
Squadron D	Portland and Portsmouth.
Squadron Y	Scilly Islands.
Squadron Z	Channel Islands.

At the time appointed the main fleets will proceed to sea for the preliminary cruise, during which the ships of each fleet will be exercised and anchored at the discretion of the admiral in command.

On the same day the special squadrons will proceed to sea independently for a preliminary cruise, during which each squadron will be exercised and anchored at the discretion of the senior officer.

No vessels except destroyers and torpedo boats are to coal after July 21 until hostilities commence.

The dates for the commencement and termination of hostilities will not be made known beforehand, but they will not begin before midnight July 28-29. After that hour the order to commence hostilities may be expected at any time. Both battle squadrons, which are to include all battleships, accompanied by such cruisers and smaller vessels as the admirals in command consider it desirable to keep with the main fleets, are to be at sea at that hour and date to the northward of the fifty-sixth parallel, Fleet B in the North Sea and Fleet X to the west of Scotland. Both fleets are then to cross the fifty-sixth parallel and enter the maneuver area.

The special squadrons are to be at their bases at midnight July 28-29, after which they will be at liberty to put to sea in accordance with such orders as they may have received.

On the conclusion of the maneuvers the ships and vessels will proceed to carry out target practice, separately in the case of the mobilized ships, ample time being

allowed for the careful performance of the practice; in the case of other ships, separately or in company, at the discretion of the admiral in command.

One-half of a quarter's allowance of ammunition is to be expended from the heavy, light, quick-firing, and machine guns of the mobilized ships.

A full quarter's allowance of ammunition may be fired from destroyers and torpedo boats if considered desirable by the senior officer.

Only such naval stores as are necessary to keep destroyers and torpedo boats efficient during the maneuvers are to be embarked in the depot vessels *Hecla*, *Mersey*, and *Thames* during the mobilization. No ordnance or torpedo-depot stores will be required.

Greenwich mean time is to be kept during the maneuvers by all ships taking part.

A copy of the ship's and signal log of every vessel taking part in the maneuvers, commencing on the earliest permissible date for commencing hostilities, is to be sent to the Admiralty with the report of the admiral in chief command of each fleet.

Before the commencement of the maneuvers each battleship and cruiser is to make a tracing of the maneuver area from Admiralty chart No. 2, British islands. During hostilities the track of the ship is to be carefully plotted each day. The positions at noon and where any important alteration of course is made are to be shown. This tracing is to be forwarded with the copy of the ship's log above referred to.

The signal stations marked on the special chart, issued with the instructions for the distribution of intelligence, will alone supply information during the maneuvers.

When the target practice has been completed the fleets will return to their ports of assembly—Portland and Torbay—where the ships specially commissioned will be inspected, and thence proceed to their ports for paying off.

OUTLINE OF THE OPERATIONS.

The B Fleet consisted of 12 battleships, and the X Fleet of 8, but the 8 battleships of X were far superior in modern equipment, speed, and long-range guns to those composing the B Fleet.

The B Fleet prior to the maneuvers proceeded up the east coast of England, and the X Fleet up the west coast, and neither were allowed to coal.

Both fleets of battleships were ordered to be north of the parallel of 56° north by midnight on Sunday, July 28, after which they were to proceed to the scene of conflict, though neither admiral was to be informed if war had broken out. For this they had to make their own arrangements, so that if war did break out they should be at once informed.

In the result the X Fleet first gained information as to the outbreak of hostilities, and the cruisers of X Fleet fell upon smaller forces of the B Fleet off the Scilly Islands before the latter knew that war had broken out.

Admiral Wilson's fleet made straight for the Scilly Islands, and from there sailed to overwhelm the Alderney blockaders, of whose movements he was fully informed by telegraph, as they showed themselves in full view of his signal stations in the Channel Islands.

Admiral Noel had posted these blockaders with the view of protecting his fleet from the assaults of the torpedo craft belonging to X

Fleet, which were assembled there. He himself proceeded at speed to Portland, where he had to coal, owing to the defective coal endurance of his old ships. He then proceeded to cruise in the channel in search of **X** Fleet, but received no information of their departure from the Scilly Islands until after the total defeat of his blockading force at Alderney, when Admiral Wilson had returned to the Scilly Islands.

Admiral Noel divined Admiral Wilson's object too late, but not knowing this, proceeded to Alderney in search of the enemy. Later, with authentic news, he again proceeded eastward, and Admiral Wilson proceeded to sea to meet him. The latter admiral passed not far from Admiral Noel during the night, but neither admiral was willing to bring on a night action, though Admiral Noel had everything to gain from one, owing to a bad light neutralizing the in **X** Fleet's superiority long-range fire.

The next day the steering gear of one of Admiral Wilson's battle-ships broke down. Unwilling to meet his enemy under these conditions, Admiral Wilson proceeded to Guernsey, repaired the damage to the **Mars**, and then proceeded eastward, again meeting Admiral Noel about 15 miles south-southwest of the Lizard.

Battle was joined, and the umpires decided the result in favor of **X** Fleet.

NARRATIVE OF THE UMPIRES.

In order that the dispositions of the admirals may be fully understood, the narrative of the movements of the vessels involved commences from midnight of the 28th. (See chart 2.)

1. Both admirals at that time detached the greater proportion of their main-fleet cruisers to the south, **X** retaining only the third-class cruiser **Pelorus**, and **B** the two armored cruisers *Impératrice* and *Galatée* and the second-class cruiser *Forth*.

2. **B** Main Cruiser Squadron proceeded to a rendezvous 10 miles south of Wolf Rock, where they arrived on the evening of the 28th.

Amphitrite, Ariadne, Eclair, Andromache, Apollo, Forth, Hawthorn, Latona, Meneste, Pelorus (10).

X Main Cruiser Squadron proceeded to a rendezvous 35 miles south of the Lizard, where they arrived at 4 a. m. on the 29th; they were joined at 7 a. m. by the *Intrepid* and *Iphigenia*, of **Z** Squadron, these latter having left Guernsey at midnight of the 28th.

Diadem, Hawke, Immortalité, Narcissus, Niobe, Arrogant, Metsey, Rainbow, Retribution, Pactolus (10), *Intrepid, Iphigenia* (2).

B Squadron detached the *For* and *Apollo* to reconnoiter the Scilly Islands, and *Latona* to Sennens Cove to bring news of the outbreak of hostilities. The *For* rejoined on the morning of the 29th; *Apollo* went to Sennens Cove to communicate, and then proceeded to the rendezvous, where she arrived at 10 a. m. on the 29th.

For and *Apollo*, *Latona*.

X Squadron had also detached the **Arrogant** and **Pactolus**, the former to get in touch with the wireless telegraphy at St. Marys, and the **Pactolus** on a rendezvous as connecting ship between **Arrogant** and main-cruiser squadron.

3. The weather was misty or hazy and the vision was limited to about 3 to 5 miles.

C Squadron, except *Renard*, proceeded to a rendezvous 15 miles east of St. Marys Island and were joined by their destroyers (except *Panther*) at 8 a. m. *Spartan* and *Shipwreck* went at 9 a. m. to watch the west side of the island, *Seas* watching the east.

Spartan, Shipwreck, Seas.

Fairy, t. b. d.

The destroyers then proceeded to Newlyn, except the *Fairy*, which had been detached to Sennens Cove.

Æolus, **Brilliant**,
Jason, **Sharpshooter**,
Gleaner.

Y Squadron, with **Gleaner**, were in Crow Sound ready to coal.

Melampus, *Mer-*
cury, *Serern*, *Scylla*.
Prometheus, *Leda*,
Speedwell.

4. **D** Squadron, with its destroyers, left Portland for Alderney at midnight of the 28th and took up their day positions, but shortly after moved into the night positions, owing to the thickness of the weather.

Z Squadron.

5. **Iris** stayed at Guernsey, and the remainder of **Z** Squadron, except **Iphigenia** and **Intrepid**, already detached, were at Alderney.

Furious.

Furious left the Scilly Islands at 7 p. m. on the 28th, and at 8 a. m. on the 29th was in latitude 49.12 N., longitude 3.16 W., where she remained till 8 p. m., when she moved to mid-channel position, St.

Catherines bearing N. 24 W. 40 (true), arriving there at 3.40 a. m. on the 30th, and at 8 p. m. she left for the Scilly Islands, at which place she anchored at 11 a. m. on the 31st. In the mid-channel position she intercepted the wireless messages to **B** Fleet, which she transmitted to Scilly Islands, and by taking in the messages from **Culver** she was able to decipher the code used by **B**.

6. The **X** Battle Fleet obtained news of the opening of hostilities at 1.40 p. m. on the 29th by the **Leven**, when in latitude 53.27 and longitude N. 5.30 W.; similar news was conveyed to the **B** Battle Fleet at 5.5 p. m. on the 29th by the *Onyx* when off Smith Knoll light.

Latona.

Latona.—7. The commencement of hostilities was communicated to *Latona* by the C. G. Station at Sennen's Cove at 9.20 a. m., and at 9.50 she proceeded to the rendezvous 10 miles south of Wolf Rock, where she arrived at 11 a. m.

Arrogant.

The **Arrogant** was informed by semaphore from St. Mary's C. G. Station at 9.25 a. m., the wireless telegraph being inefficient; she immediately proceeded full speed toward her rendezvous, and at 10.10 communicated the intelligence to **Diadem**, which informed **Arrogant** of **X** Main Cruiser Squadron's position and how they were standing.

8. At 9.35 a. m. **B** Main Cruiser Squadron spread for lookout duties 7.10 Wolf Rock, 3 miles N. E. and S. W. from *Edgar* 3 miles apart. (See plate 1.)
N. 50 E. 4 miles.

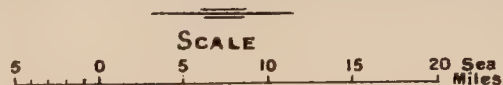
X Main Cruiser Squadron had been advancing toward **B** since 7.30 a. m., and at 11 a. m. was close to the latter's rendezvous, at which *Apollo* and *Latona* were waiting for their senior officer, of whom they could get no tidings, though *Apollo* had been there for an hour.

Shortly after some cruisers were seen by the two **B** cruisers, which steamed toward them and did not discover they were enemies for a few minutes, when they both immediately headed for Plymouth at full speed. Fire was opened by **X** cruisers at 11.15, and these two **B** cruisers had 11 vessels of **X** Main Cruiser Squadron to contend against; they were in consequence captured before any force could come to their assistance. The **X** cruisers then turned to the westward and about noon met **B**'s Main Cruiser Squadron of eight vessels, and an action ensued in which **X** Squadron were again in greater strength, for the **Arrogant** joined before the end of the action, bringing the proportion up to 12 of **X** to 8 of **B**.

	X's force.	B's force.
Armored cruisers	2	None.
First class.....	3	3
Second class	6	4
Third class.....	1	1

PLATE I.

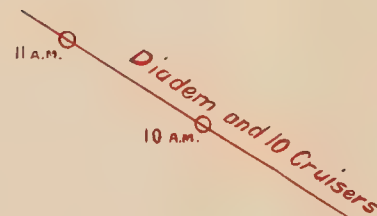
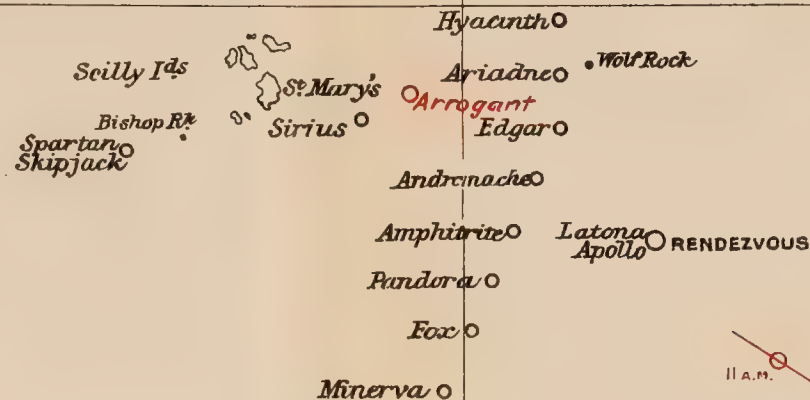
1901, BRITISH NAVAL MANŒUVRES. CHART SHOWING DISPOSITION OF CRUISERS, OFF SCILLY ISLANDS 29TH JULY (FORENOON).



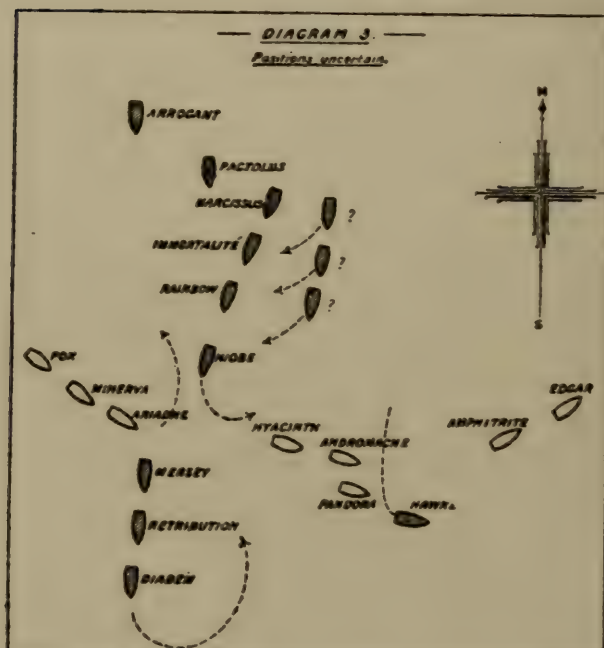
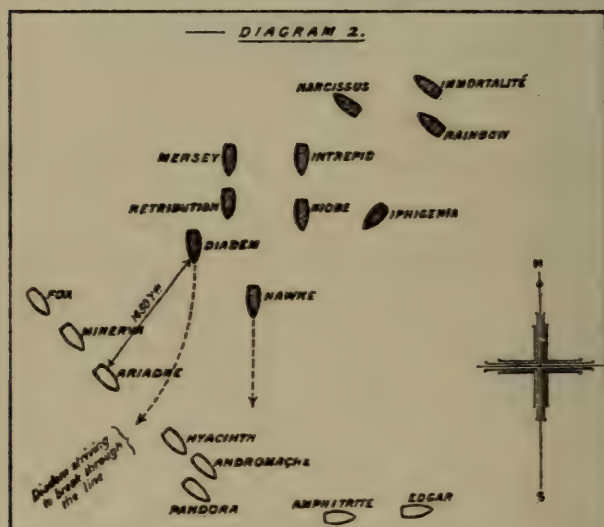
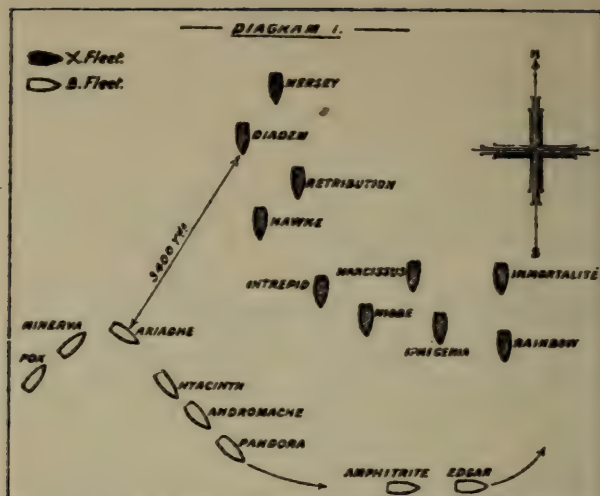
50° N.

6° W.

50° N.



6° W.



DIAGRAMS OF CRUISER ACTION OFF SULLY ISLES

The ultimate result was that 1 first-class and 2 second-class cruisers on each side were placed out of action, and in addition 1 third-class cruiser of B.

The immediate effect of these actions was that the whole of B's Main Cruiser Squadron and 8 of X's were placed out of action pending the decision of the umpires; thus C Cruiser Squadron only was left off the Scillies to contend against Y, and the 4 remaining vessels of X Main Cruiser Squadron.

According to the operations of the X Fleet, the maneuvers may be divided into three periods:

1. The cruiser engagements at Wolf's Rock and Lizard Head, on July 29.

2. The raising of the blockade of Alderney by the X Fleet, on August 1.

3. The decisive battle between the two main fleets at Lizard Head, on August 5.

Simultaneously with these, the attack and defense of commerce in the Channel were carried on.

THE CRUISER ENGAGEMENT AT WOLF'S ROCK AND LIZARD HEAD.

As soon as B discovered that the X cruisers were in force, he turned away in order to give the other ships time to form on him.

The B Cruiser Squadron had not been fully concentrated, but was proceeding in three groups: The *Edgar* as leader with the *Amphitrite*; the *Andromache*, *Hyacinth*, and *Pandora*; the *Ariadne*, *For*, and *Pandora*, attempting to form in column, in order to overtake the nucleus of the hostile cruiser squadron advancing in line abreast. This design was frustrated by the X cruisers, led by the *Diadem*, breaking through the hostile column.

The chase commenced from the moment of sighting three of the enemy's cruisers at 12.10 p. m. bearing W. S. W., the weather being hazy. (See chart 2.) Within five minutes it was evident that the X cruisers had gained so considerably that fire was opened, the enemy returning the fire after three minutes. From line abreast the position of the X cruisers had now become very scattered, and as it was seen that the three enemy's cruisers were joining up with an uncertain number of friends, the signal was made to form single line so as to have the squadron in hand. For some reason or other this signal was not passed correctly to the second division of cruisers, which, it is understood, repeated the signal as "course south." The result was delay, and it does not appear that any reduction of speed was made then or previously. The result was an action at close quarters, in which there was a good deal of independent action approaching a *mêlée*. The effect of the signal was, that when nearing the enemy the X squadron had passed from the position shown in diagram (1) to that in diagram (2).

This exposed an excellent target, but only momentarily. The *Hawke*, which, as will be seen in diagram (2), had not dropped into

station, was directed to pass through the gap in the enemy's line, but unfortunately passed through the first gap between the *Amphitrite* and the *Pandora*. The **Hawke** thus became isolated from her consorts. While the **Hawke** passed through the first gap in the enemy's line, the **Diadem**, **Retribution**, and **Mersey** passed ahead of the *Ariadne* through the second gap, causing the *Ariadne* to fear a collision and turn to port in the opposite direction to her leader, and followed by the *Minerva* and *For*. The **Niobe**, also fearing collision, refused to pass through the gap and turned to port, and she was followed by three of the **X** cruisers. The action thus became one of groups, in which the *Ariadne's* group must have been severely handled, as the **Arrogant** and **Pactolus** also came up for this latter part of the action, and this group thus received the fire of nine ships at close range.

After an hour's battle the fighting was stopped by signal from the senior officer in command of the *Edgar*. On each side 8 cruisers were declared out of action, subject to the decision of the umpires.

[Narrative of umpires continued.]

9. During this time C had been watching the Scillies, and at 11.25 *Sirius* rejoined *Spartan* and informed her that **Y** Squadron was coaling, which was the first intimation he received that hostilities had commenced. C Squadron immediately proceeded off Crow Sound. At 12.45, hearing firing to the south, C steamed off in that direction for an hour, but, seeing nothing, returned to watch **Y**, who in the meantime had put to sea; an action was fought between the two squadrons at about 2.50 p. m., which resulted in the **Brilliant** being put out of action for forty-eight hours. The *Fairy*, torpedo-boat destroyer, coming from Newlyn, joined shortly after the action commenced, but, approaching too close to **Y** Squadron, was placed out of action. The *Spartan* then left for Penzance. At 5.45 the *Sirius*, with *Renard* and *Skipjack*, were sighted and engaged the four remaining vessels of **X** Main Cruiser Squadron, with the result that the *Renard* was captured. *Spartan* left Penzance at 11 p. m. for rendezvous, where she was joined by *Sirius*, and they proceeded in company to watch Crow Sound. At 8 a. m., 30th, the **Pelorus**, whilst proceeding from St. Mary to Crow Sound, was seen and engaged by the cruisers *Spartan* and *Sirius* at a range of 800 yards until the former was within the protected area, she being placed out of action for twenty-four hours. The two B cruisers were then engaged by the four **X** cruisers, the action commencing at a range of 800 and 1,200 yards respectively, with the result that the two B cruisers were placed permanently out of action and the **Retribution**, of **X**, for forty-eight hours.

10. Thus the cruisers of B and C had been practically annihilated in the first twenty-four hours from the outbreak of hostilities.

11. After the first twenty-four hours there was a lull. Both main battle fleets arrived at their respective bases of Scilly and Portland and B immediately coaled. Round Alderney there was some fighting between the opposing destroyers, supported by cruisers, but beyond that nothing of importance occurred until the raising of the blockade of Alderney by **X** main fleet. (See chart 2.)

RAISING THE BLOCKADE OF ALDERNEY.

(See chart 3 and plates 2 and 3.)

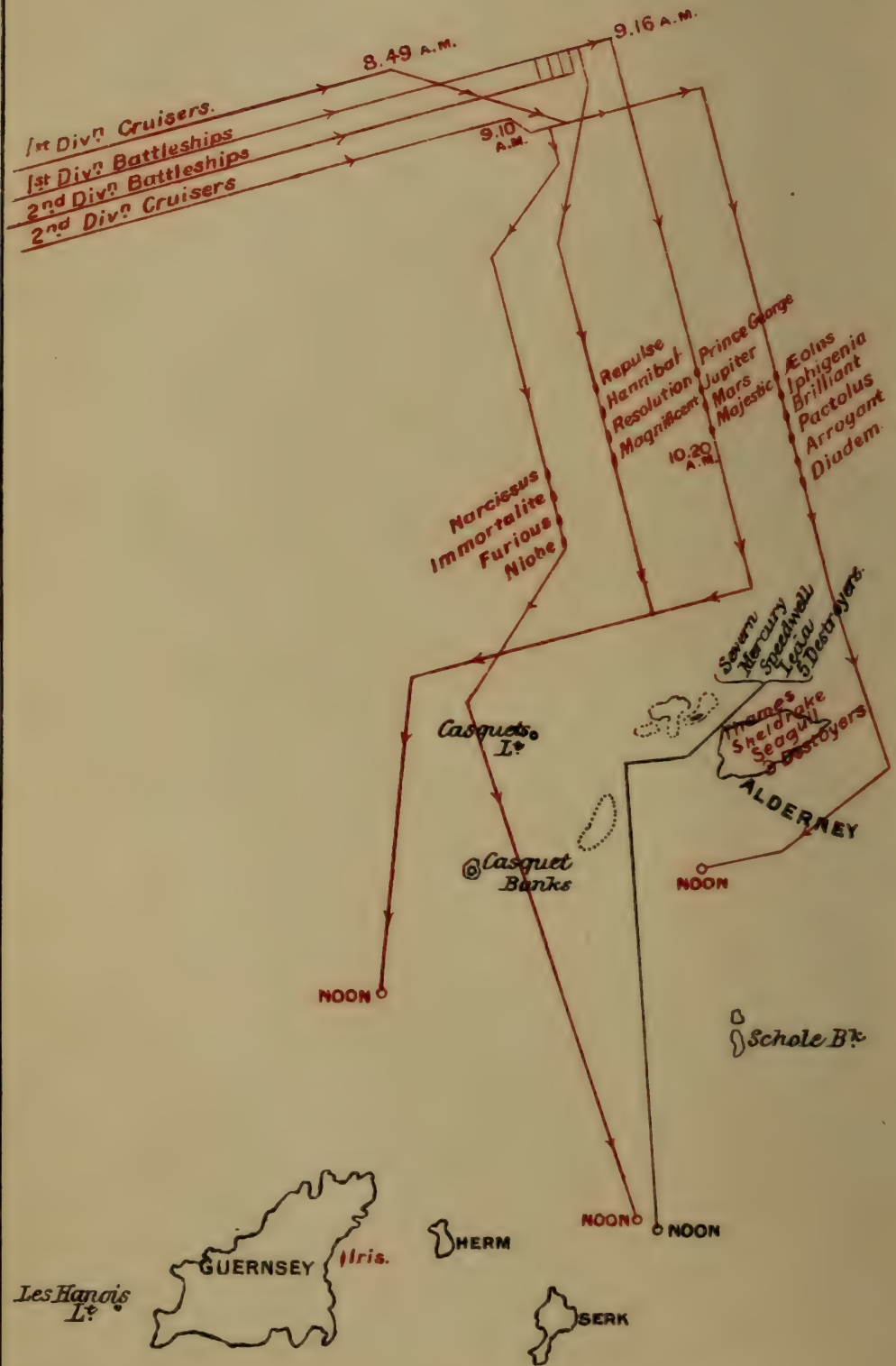
On the 31st of July, at 6 a. m., B Main Fleet left Portland, proceeding to the west in search of **X**. At 5.30 p. m. intelligence was received



PLATE 2.

X. FLEET RAISING BLOCKADE OF ALDERNEY ON 1ST AUGUST.

SCALE
5 4 3 2 1 0 6 10 15 Sea Miles



from *Hyacinth* that the **X** Main Fleet was at Scilly at 1 p. m.; the *Hyacinth* had been dispatched at that time by *Minerva*, who with *Skipjack* and *Opussum* were watching that base.

The admiral of the **X** Fleet decided to make an attempt to capture the enemy's vessels off Alderney, and intended leaving about 2 p. m., but was prevented by a thick fog from leaving until 6 p. m.

The **X** Fleet and the Y Squadron were complete, with the exception of the **Furious**, which was stationed between the Isle of Wight and the Channel Islands. This cruiser succeeded in intercepting and deciphering the dispatches which Admiral Noel, on his way to Portland, was sending to different stations by wireless telegraphy. Admiral Noel's code was with ease deciphered by the **Furious**.

Prior to the departure of the **X** Fleet from the Scilly Isles, Admiral Wilson had discussed at length with the commanding officers of his ships his plan for raising the blockade for Alderney.

After leaving Scilly at 6 p. m. (see chart 3) the **X** Fleet proceeded to the southward until 9.30 p. m., when course was altered to the eastward, speed being 13 knots.

It may here be noted that had the **X** Fleet left the Scillies at 2 p. m., as intended, and followed the same course and speed, it would almost to a certainty have been met by the B fleet between 8 and 9 p. m. that evening.

The fog cleared soon after midnight, and the fleet (**X**) continued its course up the channel until 9.16 a. m., August 1, when course was altered S. $\frac{1}{4}$ W., the fleet being then 20 miles north from Alderney. The fleet was formed in two divisions in line ahead, 3 miles apart, with the two cruiser divisions also in line ahead, 3 miles on the outer bow of its corresponding battleship division. (See plate 2.)

In this formation the fleet proceeded toward Alderney, and at 10.20 a. m. two cruisers, two gunboats, and some destroyers were sighted ahead. These belonged to the D Squadron, and at 10.26 the fleet opened fire at 4,800 yards, and shortly after increased speed to 14 knots. The weather was very hazy at the time, which enabled the **X** Fleet to approach the blockading ships without being discovered until well within range.

The blockading vessels at first ran in different directions, but finding themselves hemmed in on all sides, they turned and ran through the Swinge. (See plate 3.)

The first **X** Cruiser Division, led by the *Diadem*, wanted to follow through the same channel, but received orders to cut off the passage between the island and Cape La Hague. The second cruiser division, composed of the **Niobe**, **Furious**, **Immortalité**, and **Narcissus**, steamed around the Casquets to the west. The two battleship divisions took up positions off Swinge and Ortac channels. The swift forces of the Z Squadron followed the enemy through Swinge Channel. Surrounded

on all sides by effective gun fire at ranges varying between 3,000 and 5,000 yards, the blockading squadron, composed of two cruisers, two gunboats, and three destroyers, had to surrender. The decision of the umpires was to the effect that the B fleet had lost cruisers *Mercury* and *Severn*, gunboat *Leda*, and 5 destroyers, while the X fleet had lost only 2 destroyers and 1 torpedo boat.

Vice-Admiral Wilson remained off Alderney until 5 o'clock p. m., August 1, when he returned directly to the Scilly Islands, where he arrived the next morning without having met with any hostile forces. Here he found the cruiser *Intrepid*. He had the battleships coal from colliers in the roadstead of St. Mary's and the cruisers in Crow Sound.

MOVEMENTS OF THE B FLEET DURING THE RAISING OF THE BLOCKADE OF ALDERNEY.

At the beginning of this phase of the maneuvers B Main Fleet was at Portland.

The fleet coaled during the night, and at 5.30 a. m., July 31, the *Edgar* and *Amphitrite* went out to scout ahead of the fleet in the direction of rendezvous E (chart 3). The rest of the fleet, accompanied by 7 B destroyers (*Kestrel* under repair), left an hour later, and proceeded at 10 knots speed in the same direction. The two above-mentioned cruisers rejoined the fleet about 11 a. m., and the course was shaped to the westward, the cruisers being spread to look out.

A telegram had been sent ordering *Minerva* and *Hyacinth* (at Plymouth) to meet the fleet at rendezvous E on Wednesday morning, but owing to a mistake in the message, these two ships with *Skipjack* and *Opossum*, left Plymouth at 5 a. m. and proceeded to scout toward the Scillies. At 1 p. m. the squadron sighted the *Sharpshooter* off the Scillies and chased her into harbor; she was put out of action by the umpires for twenty four hours. The weather was very misty at the time, but in following the gunboat the *Minerva* was able to see and count the X ships at St. Mary's, and at 2.15 p. m., the *Hyacinth* was sent to inform the admiral, which she did at 5 p. m. that afternoon, and remained with the fleet until 10 p. m., when she was sent to rendezvous H with orders to wait there till *Minerva* joined, and to rejoin the fleet at 10 a. m. the next day off the Eddystone, *Minerva* to join as well if she expected to pick up no further information. The *Skipjack* was sent to communicate the information to the signal station at the Lizard, the *Minerva* and *Opossum* remaining off the Scillies. At 7.23 p. m. the *Minerva* caught sight of X Fleet outside Scilly, standing to the southward, and endeavoured to keep in touch with them, but lost sight of them in a fog and failed to pick them up again. The *Opossum* was sent to rendezvous H on the chance of being able to communicate with the admiral, and shortly after *Minerva* proceeded there herself, but, meeting no ship, she proceeded in the direction of

ACTION AROUND ALDERNEY, AUG. 1.

Channel Isles.



+++ Limits of Protected Harbors and Roads.

- - - X Fleet.

- - - B Fleet.

rendezvous E, and at 12.45 a. m. (August 1) met the *Hyacinth* and they went in company to await the fleet off the Eddystone.

The main fleet continued its course and speed to the westward until 6.12 p. m., when course was altered to the southwest and speed reduced to 8 knots; the *Hyacinth* joined at 5 p. m. At 10 p. m. the *Hyacinth* parted company, and at midnight the course of the fleet was reversed.

The fleet continued its course to the northeast until 8 a. m. when it was reversed, and the fleet exercised at tactics.

During his cruise in the entrance to the channel, Admiral Noel received the most contradictory reports as to the whereabouts of the X Fleet from the signal stations and the cruiser *Minerva*. It was not until 3 p. m. that positive information reached him from the *Minerva*, which, together with the *Hyacinth*, had been waiting since 8 a. m. at the rendezvous near Eddystone, to the effect that the enemy had left the Scilly Isles about twenty-four hours previously.

The Admiral concluded from this that the X Fleet had gone to the Channel Islands, and directed the *Melampus*, *Minerva*, and *Hyacinth* to go there, and decided to be there with the fleet early the following morning. The Main Fleet destroyers were sent to Plymouth to coal, with orders to rejoin the fleet at rendezvous E.

At 7.30 p. m. the fleet, being then off the start, the *Scylla* and five C destroyers joined. The *Scylla* had been transferred from D to take charge of C Squadron, and had arrived at Plymouth at 11.30 p. m. on the 31st, and had coaled. The destroyers were ordered to watch off Berry Head, and to return to Plymouth at daylight the next morning. The *Scylla* was attached to the fleet which cruised in Lyme Bay during the night.

At daylight Friday, August 2, the B destroyers (8) rejoined from Plymouth, and also the *Edgar* and *Amphitrite*. These two cruisers, after parting from the fleet at noon the previous day, went to Scilly and reconnoitered, going close to St. Marys Sound, where they could see what ships were in the roads, and then went to communicate with the signal stations on Lands End and the Lizard, proceeding thence up channel to rejoin the fleet. At 9.40 p. m. the *Amphitrite* was attacked by No. 98 torpedo boat, which had been shadowing the two cruisers since they left the Scillies at 4 p. m. The night was clear, with a bright moon, and the torpedo boat was fired on by the *Edgar* for some minutes before she got within torpedo range. The attack was adjudged to have failed, and No. 98 placed permanently out of action.

At 4.30 a. m. the Admiral heard of the capture of D squadron off Alderney by X Fleet.

Early in the morning the *Galatea* developed defects and went to Portland, where she arrived at 5 p. m.

The fleet then steered for the Channel Islands. At 7 a. m. the *Minerva* and *Hyacinth* joined, and shortly after these two cruisers

were sent to make sure that **X** Fleet was not in the vicinity of Guernsey. Whilst carrying out this duty the *Hyacinth*, at 10 a. m., passed through prohibited water near Guernsey (see plate 3), for which she was subsequently placed out of action. About the same time four of the destroyers were sent to reconnoiter to the eastward of the Channel Islands.

Having made sure that the **X** Fleet was not in the neighborhood of the Channel Islands, the fleet proceeded toward Portland, and about noon the cruisers and the four remaining *B* destroyers were sent on ahead to Portland. The *Melampus* joined the fleet shortly after, and she was also sent on to Portland.

The fleet arrived and anchored at Portland at 4 p. m. and coaled. The admiral was informed that **X** Fleet was back at Scilly.

MOVEMENTS LEADING TO THE FINAL BATTLE BETWEEN THE MAIN FLEETS, ON AUGUST 5. (SEE CHART 4.)

Midnight, August 2-3.—**X** Main Fleet at Scilly. *B* Main Fleet at Portland.

At 4.30 a. m. August 3 five *B* Main Fleet destroyers and four *D* Squadron destroyers left Portland, with orders to proceed 60 miles southwest of Portland and then to scout in pairs toward the entrance to the channel, and on arrival there to scout between the Scillies and *B* Fleet.

Orders were sent to the *Prometheus* at Plymouth and to the *C* Squadron to join the admiral the next morning at rendezvous H.

The *B* Main Fleet left Portland at 5.30 a. m. and proceeded at 10 knots down channel.

At 6.45 p. m. information was received that *Minerva* had been ordered out of action on claim from torpedo boats of **Z** Squadron. She was therefore sent to Portland.

At 7.10 p. m. a strange ship was seen, and the *Melampus*, *Edgar*, and *Amphitrite* chased and engaged her. This ship was the *Prometheus*, which was on her way to join *B* Fleet. Whilst chasing, **X** Fleet was sighted.

At 8.20 p. m. *B* Fleet altered course to S. S. W. and reduced speed to 8 knots.

Three destroyers (**Mallard**, **Cynthia**, and **Cheerful**) of **Y** Squadron were sent out from Scilly at 3 p. m. to find *B* Fleet.

At 5.30 p. m. **X** Fleet left St. Marys Road and proceeded to the southward at about 6 knots speed. Shortly after leaving, a gunboat and some destroyers (*C* Squadron) were seen to be watching the fleet. The first division of cruisers was sent to chase them off. Whilst chasing these vessels, the **Arrogant** came across the **Mallard**, who reported having seen *B* Fleet. This information was given to the admiral of **X** by wireless telegraphy at 8 p. m., and at 8.30 the **Mallard** joined the fleet.



The admiral, not wishing to bring on a night engagement, about 9 p. m. stood to the southward.

Several of the *B* cruisers were seen after dark, and about 11 p. m. the *Amphitrite* passed down the line of **X** Fleet at a distance of about 2,000 yards, for which she was subsequently put out of action.

The **Niobe** and **Intrepid**, two of the cruisers detached from **X** Fleet to drive off the hostile vessels which were watching the fleet when it left Scilly, lost touch of the fleet after the chase and proceeded to a rendezvous off the Start, and on the way, soon after midnight, they were attacked by some destroyers, one of which (the *Wolfe*) succeeded in getting close to the **Intrepid** and claimed to have torpedoed her. This claim was allowed, the *Wolfe* and *Hasty* being also put out of action.

At midnight *B* Fleet turned to the northward and stood toward H rendezvous.

Both of the admirals were aware that the main fleets were close together, but neither wished to engage during dark. *From the chart it would appear that about 1.30 a. m. on the 4th they were a little over 5 miles apart, X Fleet standing to the south and B to the northward.*

X Fleet steered to the southward until 2 a. m., when course was altered to the eastward and a destroyer sent to pick up the **Niobe** and **Intrepid** and tell them to join the fleet at a rendezvous 40 miles south of the Eddystone, and at 4.40 a. m. the fleet altered course to meet them there. The destroyer delivered the admiral's orders to these ships, and at 10 a. m. they rejoined the fleet.

X Fleet being now complete, was turned to the westward with the intention of finding *B* Fleet, but shortly after the **Mars's** steering gear broke down, and, finding that it could not be satisfactorily repaired for some time, the admiral decided to go to Guernsey, where the fleet (except the **Mars**) arrived at 5.30 p. m. The **Mars** arrived at 8.30 p. m.

B Fleet arrived at rendezvous H at 4.30 a. m., the scouts of *B* having lost touch of **X** Fleet. The scouting cruisers, except the *Melampus*, joined the fleet, and also *Prometheus*, *Skipjack*, *Antelope*, and 13 destroyers, namely, 7 *B*, 4 *C*, and 2 *D*. From the reports made by these vessels it was thought possible that **X** Fleet might be to the southward or southwestward of *B*; some destroyers were therefore sent to scout in that direction and the fleet stood to the southwest until 8.30 a. m., when course was altered to the northward, and about 5 p. m. to the westward. Nothing was discovered of the whereabouts of **X** Fleet except that they were not at the Scillies. During the afternoon the *Skipjack*, *Antelope*, and all the destroyers were sent to Plymouth to coal.

At 11 p. m. the fleet altered course to the eastward, and passed to the southward and in sight of the Scillies at 8 a. m. The *Speedwell* was sent to reconnoiter and reported that **X** Fleet was not at the Scillies. The *Scylla* was sent to Penzance to obtain news from

the signal station, and on the way she engaged and put out of action the **Jason** (Y). She rejoined *B* Fleet at the end of the action between the main fleets.

At 8 a. m. the *B* Fleet altered course and stood toward the *Lizard*, and at 10.15 a. m. a message was received from the *Melampus*, reporting the position of **X** Fleet. *B* Fleet then steered to cut off **X** Fleet, and about noon the main fleets sighted each other. At 1.15 p. m. the action between the main fleets commenced at a range of 7,000 yards.

The *Melampus* did not rejoin the fleet with the other cruisers, but being in communication by wireless telegraphy, continued to search for **X** Fleet.

At 7.30 a. m. she chased one of the enemy's destroyers (**Zebra**), and soon after 10 a. m. sighted **X** Fleet, and kept in touch with them until both fleets were in sight, when she rejoined *B* Fleet.

Four of **Z** Squadron destroyers (**Mermaid**, **Zebra**, **Avon**, and **Spitfire**) joined the **X** Fleet at Guernsey and were sent on to search for *B* Fleet. The main fleet weighed shortly before midnight on the 4th, and after clearing the islands proceeded on a northwesterly course at 10 knots speed to a position 25 miles south of the start, where they arrived at 5.30 a. m., and then altered course down the channel.

About 9 a. m. the following wireless messages were taken in by **X**:

"To *Rerenge*. What is your latitude and longitude?"

"Reply. Steering for the *Lizard*, 40 miles east."

Shortly after this the **Zebra**, one of the destroyers scouting for the **X** Fleet, returned and reported that she had been chased by a cruiser (*Melampus*) at 7.45 a. m., and at 10.35 the *Melampus* was sighted.

The fleets were in sight of each other at noon, steering on converging courses, both being in divisions in line ahead disposed abeam to starboard. (See plate 4.)

The **X** Fleet formed in battle line ahead on a northwesterly course, the second in command, Rear-Admiral Dyke Acland, leading the second division at the head of the column, while Vice-Admiral Wilson, on board his flagship **Majestic**, was in the center of the line. The armored cruisers **Narcissus** and **Immortalité** occupied second positions, respectively, in the two divisions. The distances between the ships were 200 yards. The first cruiser division, composed of the cruisers **Diadem**, **Arrogant**, **Brilliant**, **Niobe**, **Furious**, and **Intrepid**, followed in the wake of the battleship column at a distance of 16 cable lengths, the other four cruisers and five torpedo-boat destroyers being on the starboard side to leeward of the fire, about 5,000 yards off.

The *B* Fleet was approaching at a high rate of speed on a northeasterly course. The battleships were formed in four lines of three ships each. Rear-Admiral Noel led the second line of the left wing, Rear-Admiral Grenfell the second line of the right wing. The six cruisers, *Amphitrite*, *Edgar*, *Prometheus*, *Forth*, *Melampus*, and *Impérieuse*,



Action between Main Fleets.

PLATE

August 5th 1901.

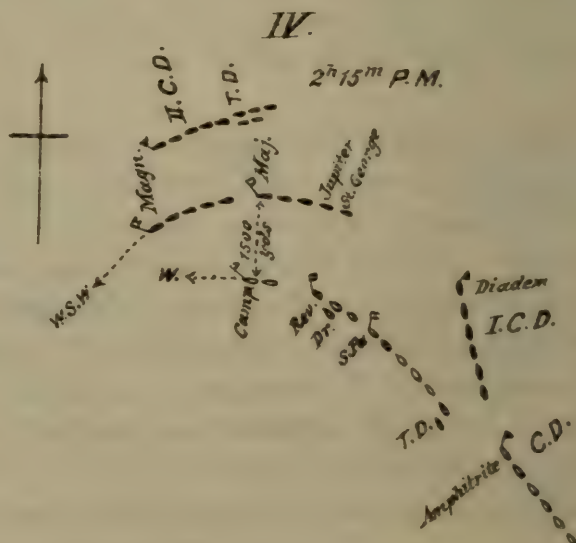
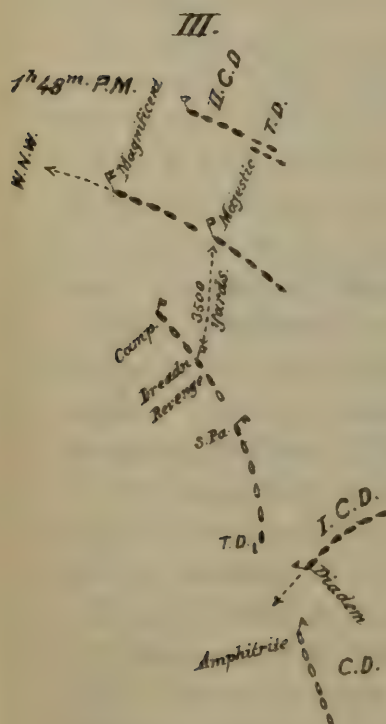


B. Fleet: ○ ○ ○ Cruiser Div.

- | | |
|----------------|---------------|
| 1. Camperdown | 1. Amphitrite |
| 2. Beirbow | 2. Edgar |
| 3. Dreadnought | 3. Prometheus |
| 4. Revenge | 4. Forth |
| 5. Trafalgar | 5. Melampus |
| 6. Nile | 6. Imperieuse |
| 7. Sanspareil | |
| 8. Howe | |
| 9. Collingwood | |
| 10. Edinburgh | |
| 11. Anson | |
| 12. Colussus | |

X-Fleet: --- I. Cruiser Div.

- | | |
|----------------|-------------------------|
| 1. Magnificent | 1. Diadem |
| 2. Narcissus | 2. Arrogant |
| 3. Resolution | 3. Britannia |
| 4. Hannibal | 4. Niobe |
| 5. Repulse | 5. Furious |
| 6. Majestic | 6. Intrepid |
| 7. Immortalité | |
| 8. Mars | |
| 9. Jupiter | |
| 10. St. George | |
| | II. Cruiser Div. |
| | 1. Paetolus |
| | 2. Aeolus |
| | 3. Iphigenia |
| | 4. Pelorus |
| | 5. Torp. Boat Dest. |



were in line ahead on the beam of the battleships. The only destroyer with the fleet was steaming to leeward off the last battleship. The distance between the ships was about 300 yards, that between the divisions about 1,200 yards. When the fleets had approached to within 12,000 yards of each other Admiral Noel swung around with the leading ships four points, then two points (see plate 4, positions I and II), so that the divisions were steaming in quarter line two points astern. Gradually he swung around farther on a northwesterly course and likewise formed in line ahead. As the result of this move and the high rate of speed of 12 knots, which some of the ships were hardly able to keep up, there was considerable confusion in the formation of the line. Vice-Admiral Wilson allowed the enemy to approach to within about 6,000 yards before opening fire. Then, taking advantage of his superior speed, he formed in a flat arc around the head of the hostile column. Toward the end of the battle he was on a west-southwesterly course (see plate 4, position IV). Admiral Noel followed the turn to the westward on an inner arc, and during the whole of the engagement he remained exposed to the enemy's concentrated fire. The regularity of the line was broken more and more. The battleship *Dreadnought* dropped so far behind that there was finally an interval of 8 cable lengths between the *Benbow* and *Revenge*. The first cruiser division of the **X** Fleet, soon after the beginning of the engagement, received orders to swing to port and place itself between the rear end of the hostile line and the cruiser group (position III). In doing so it exposed itself for some time to the fire of the heavy guns of the rear ships of the hostile column. When Admiral Wilson changed his course to the southwest the cruiser division returned to its former position in the wake of the battleship squadron, so as not to be cut off. This maneuver of the cruiser division can not be considered a success. After an hour's fighting the battle was stopped and the decision of the umpires appealed to. The distance between the lines was 1,500 to 3,000 yards. The *Jupiter* and *Prince George*, forming the rear of the column, launched torpedoes at 1,500 yards.

Almost simultaneously with the termination of the battle Admiral Noel received instructions from the Admiralty by wireless telegraphy from Lizard Head that the maneuvers were at an end. During the whole of the battle only three signals were made in the **X** Fleet and nine in the *B* Fleet.

The two fleets separated at once. Admiral Wilson steamed for Torbay by way of the Scilly Islands, Admiral Noel proceeded directly to Portland. The decision of the umpires was unfavorable to the *B* Fleet. The total losses up to the time of the decisive battle were, for the **X** Fleet, 3 cruisers, 1 gunboat, 6 destroyers, and 7 torpedo boats; for the *B* Fleet, 12 cruisers, 2 gunboats, and 12 destroyers.

COMMERCE WARFARE.

Owing to the premature termination of the maneuvers, the second part of the programme laid down in the general idea was not fully carried out. Vice-Admiral Wilson regarded the harassing of the channel commerce as of very secondary importance, so long as there was any possibility of efficient hostile squadrons making their appearance in the channel, and he employed only torpedo-boat destroyers for the purposes of commerce destruction. A merchant vessel was considered captured when a warship had steamed around it once. This rule must be regarded as too favorable for the privateer.

ORDERS GIVEN BY THE ADMIRAL OF "X" FLEET FOR CAPTURING MERCHANT SHIPS.

As the ultimate aim of X Fleet is to stop the trade in the English Channel, and St. George's Channel, and the actual conditions of chasing and capturing merchant vessels can not be exactly imitated in peace maneuvers, the following procedure is to be adopted in order to represent a capture:

I. In order that a vessel of X Fleet may claim to have captured a merchant vessel, she must take up a position at least 1 mile astern of her, and then steam completely around her, passing at least 2 cables ahead, taking care not to pass so close as to cause any anxiety or inconvenience to the merchant ship.

II. This is based on the consideration that a merchant ship will make off as soon as she discovers that an enemy's man-of-war is in sight, and will have to be chased until within the extreme range of the guns.

III. The chase in clear weather would, therefore, often have to gain 5 or 6 miles before bringing a vessel to, but, on the other hand, at night, or in thick weather, they might come under fire without any chase at all, and, even without chasing, many ships would be driven off and prevented from reaching the enemy's coast, even if they are not captured.

IV. Only British vessels are to be captured.

Merchant ships claimed by X Fleet.

The number of merchant ships claimed to have been captured by vessels of X Fleet are:

By X destroyers	154
	154
By Y gunboats	78
By Y destroyers	64
	142
By Z gunboats	9
By Z destroyers	24
	33
Total	329



ACTIONS DURING THE MANEUVERS AND CLAIMS RESULTING THEREFROM.

(See Chart 5.)

CLAIMS BY X FLEET.

Dis- tinc- tive num- bers on chart.	Date.	G. M. T.	Position.	By whom claimed.	Vessels claimed.	Decision.
1	July 29	11 a. m.	Off Wolf Rock	Diadem, Niobe, Hawke, Narcissus, Intrepid, Mersey, Retribution, and Pactolus.	<i>Latona</i> and <i>Apollo</i>	Allowed.
2	do....	12.10 p. m.	do.....	Diadem, Niobe, Hawke, Narcissus, Immortalité, Arrogant, Mersey, Retribution, Iphigenia, Intrepid, Rainbow, and Pactolus.	<i>Edgar</i> , <i>Amphitrite</i> , <i>Ariadne</i> , <i>Minerva</i> , <i>Hyacinth</i> , <i>Andromache</i> , <i>Fox</i> , and <i>Pandora</i> .	Hawke, Rainbow, Mersey, Ariadne, Fox, Andromache, and Pandora permanently out of action.
3	do....	2 p. m.	Off Scilly Islands.....	Brilliant, <i>Æolus</i> , Jason, and Sharpshooter.	<i>Spartan</i> , <i>Sirius</i> , <i>Skipjack</i> , and <i>Fairy</i>	Fairy permanently out of action. Brilliant out of action for 48 hours.
4	do....	5.45 p. m.	do.....	Immortalité, Iphigenia, Retribution, and Mersey.	<i>Sirius</i> , <i>Renard</i> , and <i>Skipjack</i>	<i>Sirius</i> and <i>Renard</i> permanently out of action. Note: Mersey was out of action previously.
5	July 30	4.35 a. m.	do.....	Gleaner and Jason	<i>Bad</i> , <i>Wolf</i> , <i>Panther</i> , and <i>Hasty</i>	Not allowed.
6	do....	8.15 a. m.	do.....	Immortalité, Iphigenia, Retribution, and Mersey.	<i>Spartan</i> and <i>Sirius</i>	<i>Spartan</i> permanently out of action. Retribution out of action for 48 hours. Note: Mersey and <i>Sirius</i> previously out of action.
7	do....	8.30 a. m.	do.....	Jason	<i>Bad</i>	Allowed.
8	do....	10.30 a. m.	Off Alderney.....	Thames, Seagull, Sheldrake, and 12 destroyers.	<i>Mercury</i> , <i>Scylla</i> , <i>Leda</i> , and 18 destroyers.	Four destroyers on each side permanently out of action.
9	do....	11 p. m.	Alderney	Thames	<i>Bullfinch</i> and <i>Dove</i> , for entering Alderney Harbor.	Allowed.
10	July 31	9 a. m.	Off Alderney.....	Ariel, Albatross, Avon, Snapper, Spitfire, Bittern, Mermaid, Contest, Dasher, Haughty, Porcupine, and Zebra.	<i>Spitfire</i> , <i>Dove</i> , <i>Electra</i> , <i>Hunter</i> , <i>Sylvia</i> , and <i>Bullfinch</i> .	Five destroyers on each side to be put out of action for 48 hours.

ACTIONS DURING THE MANEUVERS AND CLAIMS RESULTING THEREFROM—continued.

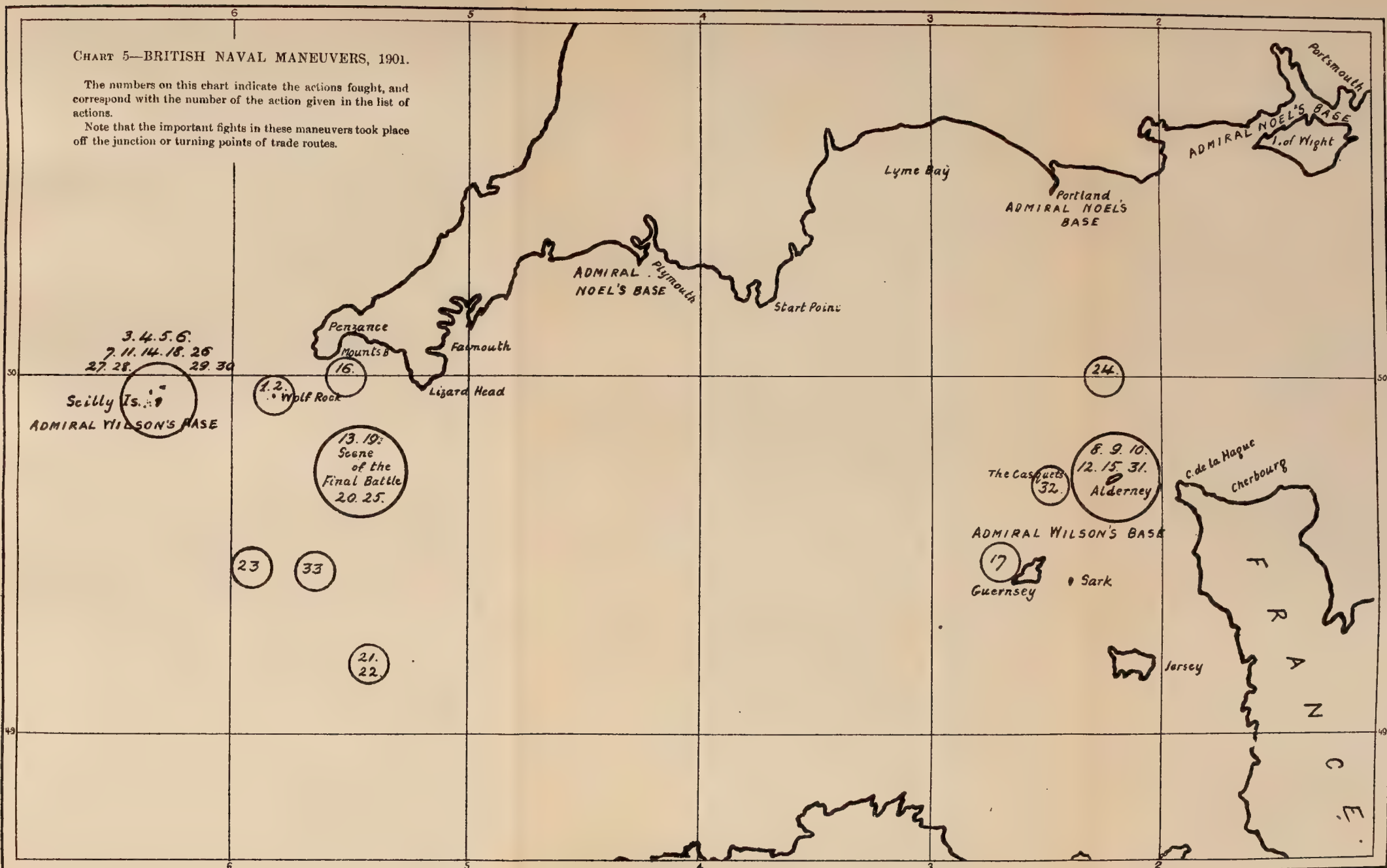
CLAIMS BY X FLEET—Continued.

Distinctive numbers on chart.	Date.	G. M. T.	Position.	By whom claimed.	Vessels claimed.	Decision.
11	Aug. 1	4.45 a. m.	Off St. Agnes, Scilly Islands.	Gleaner	<i>Opossum</i>	Not allowed.
12	do....	11 a. m.	Off Alderney.....	X Fleet	<i>Severn, Mercury, Spectuel, Leda, Starfish, Brazen, Wizard, Surlly, and Teazer.</i>	Severn, Mercury, Leda, Starfish, Brazen, Wizard, Surlly, Teazer, Ariel, and Albatross permanently out of action.
13	do....	4.15 p. m.	Off the Lizard.....	Torpedo boat No. 98	<i>Edgar and Amphitrite</i>	No. 98 torpedo boat permanently out of action.
14	do....	9.40 p. m.	Off the Scilly Islands.....	Intrepid	<i>Skipjack</i>	Not allowed.
15	do....	10.35 p. m.	Off Alderney.....	Torpedo boats Nos. 55, 82, 85, and 86	<i>McLampus, Minerva, and Hyacinth</i>	Minerva and torpedo boats Nos. 55, 82, and 85 permanently out of action.
16	Aug. 2	7.13 a. m.	Off Penzance.....	Jason	<i>Skipjack</i>	Not allowed.
17	do....	10 a. m.	Off Guernsey.....	Iris	<i>Hyacinth, for passing through Great Russell Channel.</i>	Allowed.
18	Aug. 3	1.15 a. m.	Off Scilly Islands.....	Lee	<i>Panther</i>	Lee out of action for 48 hours.
19	do....	5.25 a. m.	Off the Lizard.....	Salmon, Angler, Sturgeon, and torpedo boats Nos. 61 and 76.	<i>Antelope, Panther, Wolf, Shark, Hasty, and Opossum.</i>	Torpedo boats Nos. 66 and 76 permanently out of action. Salmon, Angler, Sturgeon, and Panther out of action for 48 hours.
20	do....	6.35 a. m.	Off the Lizard.....	Torpedo boat No. 58	<i>Antelope, Panther, Shark, and Hasty</i>	Torpedo boat No. 58 permanently out of action.
21	do....	10 p. m.	Latitude 49° 12' N., longitude 5° 28' W.	Niobe and Intrepid	A destroyer, name unknown.....	Not allowed.
22	do....	11.50 p. m.	do....	do....	<i>Hasty and Wolf</i>	Intrepid, Hasty, and Wolf permanently out of action.
23	do....	10.40 p. m.	Latitude 49° 25' N., longitude 5° 52' W.	X Fleet	<i>Amphitrite</i>	Allowed.

CHART 5—BRITISH NAVAL MANEUVERS, 1901.

The numbers on this chart indicate the actions fought, and correspond with the number of the action given in the list of actions.

Note that the important fights in these maneuvers took place off the junction or turning points of trade routes.



24	Aug. 4	12.37 p.m.	Latitude 49° 57' N., longitude 2° 15' W.	Snapper and Bittern	A destroyer, name unknown	Not allowed.
25	Aug. 5	1 p.m.	Off the Lizard	X Fleet	B Fleet	Decided in favor of X Fleet.
CLAIMS BY B FLEET.						
26	July 29	12.30 p.m.	Off Crow Sound	Spartan and Skipjack	1 torpedo gunboat and one torpedo boat, names unknown.	Not allowed.
27	do....	1.30 p.m.	Off the Scilly Islands	do....	1 destroyer, name unknown	Do.
28	July 30	1.15 a.m.	Off St. Marys Sound	Bat and Hasty	do....	Do.
29	do....	8 a.m.	The Cove, St. Agnes, Scilly Islands.	Spartan and Sirius	Pelorus	Pelorus out of action for 48 hours.
30	July 31	12.15 p.m.	Off St. Agnes, Scilly Islands	Minerva, Hyacinth, Opossum	Sharpshooter	Sharpshooter out of action for 24 hours.
31	do....	9.55 p.m.	Off Alderney	Charger	1 torpedo boat, number unknown	Not allowed.
32	Aug. 3	7.45 p.m.	Off the Casquets	Onyx	Seagull	Do.
33	Aug. 5	7.50 a.m.	Latitude 49° 30' N., longitude 5° 39' W.	McLampus	1 destroyer, name unknown	Do.
34	do....	11.30 a.m.	Off Longships Lights	Scylla	Jason	Allowed.

A GERMAN VIEW OF THE MANEUVERS.

[From the *Marine Rundschau*.]*1. Object of the maneuvers and dispositions of the Admiralty.*

Judging from the general idea and the special instructions, it was apparently the intention of the Admiralty to gain enlightenment as to the following points:

(a) In what manner can the problems of gaining control of the sea in the Channel and protecting the Channel commerce be combined?

(b) What fighting means are necessary to that end and how are they to be employed?

(c) In what manner are the operations affected by the necessity of renewing coal supplies?

(d) In how far can wireless telegraphy be employed as a means of communication in war?

The conviction that the struggle for the control of the sea is a necessary prerequisite to any other warlike operation and must take first place has, in no other country, taken such a hold on the people as in England. And yet, owing to the fact that England's existence is conditioned upon the unimpeded importation of food supplies and the further circumstance that a great part of the national wealth is floating on the sea, she will, in case of war, from the very beginning of hostilities withdraw forces from the battle fleet in an endeavor effectually to protect her commerce. This tendency will become the more apparent the better and longer the hostile fleet is able, by the rapidity of its movements, to elude a decisive battle. The distribution of the fighting forces to the different parties shows that this contingency is reckoned with in England. If in case of war with France the Channel Squadron were sent to reenforce the Mediterranean Squadron, the protection of the Channel and of the Channel traffic would be left to the reserve squadron, composed of obsolete types of ships.

By prohibiting the ships from coaling between July 21 and the beginning of hostilities and by instructing the main fleets to be stationed at midnight of July 28 about 500 miles from their nearest base of operations, it must have been intended to simulate either an advanced stage of a struggle or a sudden breaking out of hostilities for the purpose of obtaining additional light on the important question of coaling large naval divisions. The assumption that, as the result thereof, the scene of action was not to be sought in the Channel but in the Mediterranean is not consistent with the general idea.

The disposition that the umpires were to be in London has proved in this year's maneuvers even more inexpedient than in previous years. In order that the operations might represent as nearly as possible actual conditions of war, the final decisions should have been announced immediately after each engagement. Owing to the delayed receipt of

the decisions it was impossible for the admirals to form immediate plans, as they did not know what fighting forces they would have to deal with, both on their own side and on that of the enemy. The immediate utilization of results is too important a factor in war to be neglected in peace maneuvers.

The staffs did not have a sufficient number of officers possessing the necessary experience in the strategic and tactical employment of large divisions of ships. The complete failure of the scouting cruisers of the B Fleet must be ascribed wholly to this deficiency.

2. Operations of the fleets.

The wording of the general idea prescribed to the two commanders in chief their course of action, as it were, first of all, attainment of the control of the sea, and then attack and protection of the Channel traffic. Both admirals, during the whole of the maneuvers, bore this gradation in mind, but only the commander in chief of the X Fleet realized its full import. Admiral Wilson knew that he could not fight the inevitable decisive battle until he had weakened the enemy by partial defeats. During the first period of the struggle it was not the enemy's main fleet that was to his mind the principal objective of attack, but the cruiser fleet. The latter he could meet with at least equal forces. If he succeeded in defeating it he insured to himself freedom of movement and rendered it impossible for the commander in chief of the B Fleet to force him to a decisive battle against his will. By the immediate incorporation of the cruisers **Iphigenia** and **Intrepid** into the cruiser divisions of the main fleet he sought to attain numerical superiority, which is so important a factor toward success. The attack upon the enemy's commerce remained in his eyes a matter of secondary importance. His clear perception of the situation transmitted itself, as a matter of course, to the officers commanding his ships. The commanding officer of the **Diadem**, upon meeting with the hostile scouts at noon of July 29, knew that he must first make sure whether he had to deal with superior or with inferior forces, and in the latter case bring about a decisive battle.

It was also a correct step for the X Fleet to remain at the Scilly Islands until the final decision as to the cruiser engagements at Wolf's Rock and Lizard Head became known. The success of the plan for raising the blockade of Alderney was conditioned essentially on a reliable information service as to the movements of the hostile battleship squadron. The losses sustained were made up by Admiral Wilson, as far as possible, by transferring the cruisers **Brilliant** and **Æolus** of the Y Squadron to the cruiser divisions of the main fleet and retaining those divisions with the nucleus of the fleet. The only thing that must seem strange is that during his stay of a day and a half at the Scilly Islands he did not have the ships recoal; at least, the reports do not mention anything to that effect.

When the D Squadron had been completely defeated at Alderney, the hostile cruiser fleet ceased being an all-important objective. Vice-Admiral Wilson now had to make up his mind to fight the decisive battle with the main fleet in order to solve the first part of the problem set before him. But he avoided the unfavorable opportunity during the night of August 3, because at night he could not utilize to the full extent the superior range of his guns.

The same good judgment and energy which Admiral Wilson had displayed in the strategic employment of his forces he also showed as tactical commander. His operation toward raising the blockade of Alderney was well calculated to place the hostile D Squadron into his hands if he could surprise it. In order to win the decisive battle at Lizard Head on August 5, he had to utilize the superiority of the armament of the individual ships and the superior speed of the fleet and seek to impose upon the adversary a battle at long range. He brought the enemy into the center of the effective fire of his ships and then fired upon him at ranges between 1,500 and 6,000 yards. Three points are especially to be noted: His commanding the battleship squadron from the center of the line; the incorporation of the armored cruisers **Immortalité** and **Narcissus** into this squadron, and the placing of a special cruiser division in the wake of the column. The position of the admiral in the center is probably the most favorable one for carrying on a battle with large guns. It gives him a better chance to see what is going on than from the head of the column. The incorporation of the two armored cruisers into the homogeneous squadron of battleships was probably effected in view of the inferior fighting efficiency of some of the battleships of the B Fleet. Moreover, it is preferable, from a tactical standpoint, to assign to ships of inferior fighting efficiency a place in the middle of a line rather than at its ends. By the formation of a special cruiser division for the support of the battleships, Admiral Wilson apparently wanted to ascertain by experience in what manner a squadron composed of modern cruisers can take part in an engagement between battleships. It is hardly reasonable to assume that he had in mind above all the destruction of the still available cruisers of the B Fleet, otherwise he would not have kept four cruisers inactive as a reserve.

Of the torpedo-boat destroyers Admiral Wilson does not appear to have had a very high opinion. While he reenforced his main fleet with the cruisers of the Y and Z squadrons, he does not seem to have attached the same importance to doing so in the case of the destroyers. To them he intrusted the attack upon the enemy's commerce, which in the first stage of the struggle he considered a secondary operation. Whether he deemed these vessels especially suitable for the purpose is an open question, but it is hardly to be assumed. His cruises between Alderney and the Scilly Islands even show a rather low opin-

ion of the efficiency of these vessels, which can not boast of any great successes in the maneuvers. The question of the best tactical employment of torpedo-boat destroyers has not been brought nearer solution by him.

An energetic will based on clear judgment, rapidity of movements supported by good information service, and concentration of forces at the points of probable encounter made Admiral Wilson master of the Channel after eight days' fighting and would have enabled him, in case the maneuvers had been continued for some length of time, to cripple materially the traffic in the Channel.

The task which fell to the share of the commander in chief of the B Fleet, Rear-Admiral Noel, was by far the more difficult one. It was not nearly so easy for the latter to decide upon letting the English commerce in the Channel take care of itself and drawing to himself all the available forces for the decisive battle with the main fleet as it was for Vice-Admiral Wilson to desist from an effectual attack upon commerce. The former knew that the Admiralty wanted to collect experience as to whether and in what manner the reserve squadron with the small fighting forces which would be at its disposal in case of war would be able, simultaneously with the struggle for supremacy in the Channel, to protect the Channel traffic; his position was a forced one, so to speak. Still in many respects his course of action can not be approved. An erroneous appreciation on his part of the efficiency of his own and of the enemy's fighting means led to more scattering than was necessary. The greatest mistake was made in the employment of the scouting vessels, which for his fleet being inferior in speed, were in spite of the cooperation of the signal stations of even more importance and value than for the enemy. A safe and well-organized information service was the first prerequisite to the success of the plan of forcing the faster X Fleet to a battle and drive it out of the Channel. Admiral Noel ought to have kept strong cruiser forces constantly with his fleet. Instead of that he detached nearly all the cruisers belonging to the main fleet as early as July 27 at the western entrance to the Channel; only three of the older cruisers remained with the battle squadron. By detaching the cruisers he deprived himself of the possibility of energetic reconnoitering in his advance into the Channel; and by holding back three cruisers he weakened the group detached to such an extent that in case of an encounter with the hostile scouting vessels the former would presumably be numerically inferior. The danger of meeting with superior cruiser forces in the western entrance to the Channel was very great in view of the proximity of the hostile bases of operations, the Scilly and Channel islands. Nor was the cruiser group strong enough for the effectual protection of commerce. In any event, Admiral Noel should have instructed the cruisers to risk an engagement only in case they could

count on a victory with small losses. Such an opportunity did not present itself at Wolf's Rock. In spite of the heavy weather, the commanding officer of the *Edgar* must have become aware very soon that he had to do with a strong cruiser division. When Admiral Noel steamed through the Channel he realized himself that he did not have enough scouting vessels. Communication with the signal stations by means of wireless telegraphy and carrier pigeons failed. The highly important news of what had happened at Lizard Head and Wolf's Rock did not reach him until twelve to eighteen hours later.

A further mistake at the very beginning of the maneuvers was the observation of the Z Squadron at the Channel Islands by inadequate forces. As the cruiser *Prometheus* had to be left behind at Portsmouth, the D Squadron was superior to the Z Squadron by only three destroyers. The reinforcement by the torpedo-boat flotilla of the main fleet was not sufficient. If Admiral Noel deemed it necessary to blockade the Z Squadron in order to protect his advance to Portland and the English traffic in the Channel, he ought to have had the C Squadron reinforce him. For the observation of the Z and Y squadrons at such positions as the Channel and Scilly Islands his forces were inadequate. In any event, he should have abandoned the blockade of Alderney after the defeat of his cruiser division at Wolf's Rock.

During his advance toward and through the western entrance to the Channel, we note once more the complete failure of the scouting and information service. In spite of the scarcity of cruisers, the torpedo-boat destroyers, as far as known, were used very little for these purposes. The cruiser groups were not strong enough to maintain touch with a fast fleet surrounded by numerous cruisers, and at the same time keep the admiral informed. The commanding officers of the cruisers apparently did not fully understand their mission. At least the conduct of the *Edgar* and *Amphitrite* on the evening of August 3 is difficult to understand. Here are two large cruisers running off to inform Admiral Noel of the whereabouts of the X Fleet, leaving the *Melanpus* alone to maintain touch.

The second principal reason why Admiral Noel did not succeed in coming upon the enemy or interfering with his movements must be sought in the choice places of rendezvous and routes. In these maneuvers Admiral Noel did not follow out the principle generally advocated in England that the boundary of the home country is the hostile coast and that the enemy must be hunted up and beaten or blockaded there. When he took up his position at the western entrance to the Channel for the first time, he remained during the night in the vicinity of the signal stations of Lizard Head, Rame Head, and Start Point; the second time it was only toward the end of his stay there that he advanced as far as the vicinity of the Scilly Islands. At night he always sought to gain the open sea. In the absence of scouting vessels, Admiral

Noel, even at the risk of a torpedo-boat attack, should have remained in the immediate vicinity of the hostile base of operations. Contrary to his adversary, he seems to have had a high opinion of the efficiency of torpedo craft at night, although in other respects he has not made great demands upon them either.

While we can not approve of Admiral Noel's course of action from a strategic standpoint, his tactical leadership must in the main be acknowledged to have been correct. The B Fleet, being inferior in armament, could fight the enemy effectually only at short range. But even here there are three points which evoke criticism: The late formation in battle array; the position of the flagship as fourth in the line; and the swinging around on the same course as the enemy's for a running fight.

A fleet seeking close action must come up to the enemy in as close formation as possible and therefore the battle formation must be effected early. As the fleet in making the attack exposes itself to a superior fire, the success of the approach, aside from the speed, depends on good leadership. The admiral in command should not relinquish his place at the head of the line because his ship will suffer the most. The running fight on an inner arc was for the B Fleet the most disadvantageous mode of fighting.

As to their performances from the point of view of seamanship, both fleets deserve unlimited praise. The X Fleet especially navigated with great skill and safety. Although fog and dark weather prevailed and the waters of the Channel and Scilly Islands are among the most dangerous, the fleet of 162 vessels had only two minor accidents: The running aground of the torpedo-boat destroyer *Viper* at the Casquets on August 3 in the fog, and of torpedo boat 81 at the Alderney breakwater on August 1. The crews and the greater part of the stores were rescued. Only one ship, the cruiser *Intrepid*, lost touch with the fleet.

3. *The matériel.*

Except for the fact that the older battleships of the B Fleet are no longer well adapted for modern naval warfare, all the ships placed in commission for the maneuvers were, on the whole, equal to the demands made upon them. Of the 20 battleships the *Mars* alone sustained a slight injury to her steering gear and the *Camperdown* to her engines. The average speed of the X Fleet was 13 knots, that of the B Fleet between 10.5 and 11 knots. In the case of the cruisers, engines and boilers were disabled more frequently. Besides the cruisers *Arrogant* and *Pelorus*, which had to be left at the shipyards at the beginning of the maneuvers, 6 of the 60 cruisers and gunboats had to proceed into port for repairs. The injuries were of a light character. Only on board the *Galatea* the engines gave way entirely. Among the flotillas of a total of 60 destroyers, 16 accidents occurred, namely, 12

injuries to engines and boilers, 3 collisions, and 1 destroyer touched bottom. In view of the fact that 32 cruisers and gunboats and 34 destroyers were put in commission for the maneuvers after only an hour's engine trials, the percentage can not be regarded as extraordinarily high. Any other modern fleet would, under the same circumstances, have shown no better results.

4. *The coaling appliances.*

Each of the two fleets had at its disposal 5 colliers which had often been used before for the purpose of coaling ships. Besides these, the B Fleet used coal lighters. It is to be regretted that but little has been learned of the performances of individual ships in this respect. In the case of the *Revenge* it took about nine hours to take on 400 tons from a collier at night, owing to the fact that the steam winch had become disabled. The number of hoisting appliances on board the colliers and ships appears to have been inadequate.

5. *The signaling means.*

The intention of the Admiralty to equip all the battleships and cruisers with wireless telegraph apparatus was not carried into effect. Admiral Noel employed this method of signaling, especially in communicating with the signal stations, but not with great success. The cruiser **Furious** succeeded very soon in finding the key to Admiral Noel's messages. Before it will become entirely serviceable for war purposes, this system of signaling will require a number of further improvements. Moreover, its use necessitates well-trained personnel.

The night signaling system has either failed to function in many cases or it has not been properly managed. Off Portland as well as off Plymouth the destroyers of the home party were recognized too late. During the night of August 3 the destroyer flotilla of the B Fleet went up to the **Niobe** under the impression that it was a cruiser of its own party.

THE LESSONS TO BE DERIVED.

1. Judging from the course of the maneuvers, the question as to whether the reserve squadron in its present composition, with the small fighting forces available, will be able to defend the Channel and the Channel traffic from a hostile fleet, numerically inferior, but composed of modern ships, must be answered in the negative. Whether the results of the maneuvers would have been the same if the commander in chief of the B Fleet had from the very beginning devoted all the fighting forces at his disposal to driving the enemy from the Channel, is an open question. In any event, England will do well to replace the reserve squadron as early as possible by a squadron of

modern ships with a strong cruiser division if the protection of the Channel and of the Channel traffic is to be left to the reserve squadron alone.

2. The maneuvers have plainly demonstrated the extreme importance of a good scouting and information service for the free movements and success of modern fleets, but they have also shown that this branch of the service has been much neglected during the last few years in England, as well as in other navies. All effort has been concentrated on the tactical development of the battleship squadron. In the opinion of the English professional press it is high time that amends be made for this neglect. Special attention will have to be devoted to the choice and training of cruiser commanders. Energetic officers of clear judgment and free from any false ambition are the only ones suitable for that purpose.

As to the composition of cruiser groups, the maneuvers furnish perhaps the following suggestions:

(a) A cruiser group should, as far as possible, consist of similar cruisers.

(b) Large cruisers are best adapted for strategic scouting outside of the field of action of the battle fleet, small cruisers for tactical scouting and for safeguarding the route of the battleships.

(c) The groups should always be strong enough to enable them to maintain touch and make reports.

3. As to the efficiency and mode of employment of torpedo-boat destroyers, the opinions are as yet very diverse in England. This year's maneuvers have contributed nothing toward clearing up this point.

4. It is absolutely necessary that those who are designed to act as commanders in chief in case of war should in time of peace be kept in constant mental communication with their future subordinates, and, further, that they should be given frequent opportunities for practical command.

5. In spite of the excellent seamanship of her corps of naval officers, England can not dispense with a superior school for the sciences of naval warfare.

TARGET PRACTICE AND INSPECTIONS.

The target practice and inspections passed off without any noteworthy occurrences. The ships placed in commission for the maneuvers held their target practice separately. The Admiralty had granted, in the case of battleships and cruisers, one-half of the quarterly allowance of ammunition, and in the case of destroyers and torpedo boats the full quarterly allowance. The inspections were made by the commanders in chief of the respective fleets.

CONCLUSION.

The maneuvers were very much to the point and are among the most instructive held during the last decade in the British or any other navy. By the freedom of action granted the admirals the conditions were made to resemble as nearly as possible those of actual war. The accounts which have appeared in the daily press and professional publications have not been as complete and exhaustive as in previous years. The report submitted to the Admiralty by the umpires is very short and assigns no motives to the decisions of the commanders in chief.

Hence the idea which we are able to form of the maneuvers may not in every point correspond to the actual facts. But the conclusions arrived at will hardly be essentially affected thereby. In any event, the opinion probably still holds good that the personnel and matériel of the British navy is efficient in every respect and that as to the leadership of large divisions of ships this navy may serve as a pattern.

NOTES FROM VARIOUS ENGLISH PAPERS.

"Since he took over command of the Channel Squadron Vice-Admiral Wilson, V. C., has paid close attention to the working of wireless telegraphy in ships at sea. Day after day he spent as much time as possible in the "wireless room" of the battleship *Majestic*, his flagship, studying the instruments until he had got to know all about the system and its possibilities. When "war" was declared Vice-Admiral Wilson very cleverly turned to account his thorough grasp of the new method of signaling. To the signal staff of his flagship he gave orders that they should not work their own wireless instruments, but should use these to read off the messages transmitted between the enemy's ships when the latter were near enough for their "talks" to be intercepted. It is common knowledge that if one ship is trying to communicate with another by means of wireless telegraphy all ships or stations in the same field fitted with Marconi's instruments receive the message. The big defect of the system, in fact, is that messages can not be "screened off" so that they will reach only the ship for which they are intended. By thus using his wireless telegraphy instruments as ears instead of tongues, Vice-Admiral Wilson was enabled to gather a good deal of valuable information about his opponent. Sir Gerard Noel, the commander in chief of B Fleet, it appears, adopted the ordinary naval code for his war signals, with the slight alteration that instead of making only three letters he made five, two of which were dropped when deciphering the message. It did not take the signalmen of X Fleet long to get the key to B Fleet's code sufficiently to read all of its messages that were picked up by their instruments. In fact, Vice-Admiral Wilson had the advantage of being able to sit in his cabin and read the messages that were passing between the enemy's ships. But he took good care to issue for his own fleet a code that could not be deciphered by the foe, even if he intercepted the message.

But probably the most important lesson respecting wireless telegraphy which the maneuvers taught is that it is rather a drawback than an advantage to have every cruiser in a fleet fitted with an installation. In time of war cruisers would scout in divisions. The units of each division would keep within usual signaling distance of one another, and it would, therefore, be quite sufficient if one ship in the division possessed a set of wireless instruments."

"There is one further point of considerable importance and in dispute. It will be impossible to work the signal books in action, but it may be possible to work single flags, and the fewer the better. It goes without saying that what we are going to do in action we should practice while we can. Neither fleet used wireless telegraphy during the action. The enemy B made nine signals by flags during the action. We, X, made three signals, to individual ships, one to the cruiser division and eight general signals. Our longest signals consisted of two hoists of seven flags. Admiral Noel's longest signal consisted of five flags. Each admiral had to negative a signal during the action, a proceeding which might be difficult in real war."

"Apart from personal considerations, two things at any rate should be learned. The one is the increase of the facilities of coaling at our naval ports. It is not long since it was pointed out in our notes on "The Services" that at no port was there adequate preparation for coaling a squadron. Ship may fight against ship as to which can get the greatest number of tons on board in the shortest time; but this is merely an exercise. It almost implies one ship coaling at a time, and how feeble this is the recent maneuvers have demonstrated. It ought to be possible to coal half a dozen ships at once at Portsmouth, Portland, or Plymouth—but it is not, and in war time we should pay the penalty. This is one of the lessons of the maneuvers which ought to be severely laid to heart, and in regard to which amendment ought to be made at once. But what about scouting? Was it properly carried out? Certainly not. Is there any single manual, with Admiralty sanction or without it, which tells how it ought to be conducted? Again the answer is, certainly not. Yet scouting is one of the most important operations of war; a knowledge of it does not come by intuition; and some reasonable endeavor to elucidate its possibilities should surely form part of the teaching of the navy."

"We have mobilized 29 ships and 56 torpedo craft, and we have found 12,200 officers and men to man the ships. How has it been done? The *Cressy*, a commissioned ship, has been left with a hundred hands as a care-and-maintenance party. Men entitled to foreign-service leave have been drafted to ships. Every man on leave has been recalled. The depots and schools are left to deck scrubbers and lamp trimmers. At few previous mobilizations have we raised such a modest total as 12,200 men, and never has that number been raised with so much difficulty. And were we at real war instead of playing a game, how could we supply casualties except from the reserve, which everyone agrees is the most doubtful quantity in the service? We commend this appalling condition of things to the serious consideration of the navy league. The charter of that organization is the popularizing of the navy. The Admiralty must, of course, play their part of the game, and they must make the service more attractive. In the meantime we can dispense with the league's strategic disposition of fleets, while the nation would be grateful for a few more thousand ratings."

THE NAVAL WAR COLLEGE.

"The maneuvers serve to show the advantage resulting from a very small expenditure on a naval war college, for there we can have thought and mutual discussion among officers as to how to act under circumstances such as occurred in the last maneuvers."

A discussion of the maneuvers, from a British point of view, is given in Brassey's Annual, 1902.

X Fleet.

[Vice-Admiral Sir A. R. Wilson; Rear-Admiral Sir W. Dyhe Acland.]

MAIN FLEET.

[In the text names of vessels of the X fleet appear in heavy type.]

	Class.	Name.	Launched.	Displacement.	Speed.	Coal.	Commissioned.	Accidents during maneuvers.
	BATTLESHIPS.			Tons.	Knots.	Tons.		
1	Battleship, first class	Majestic (flagship)	1895	14,900	17.8	1,850	1895	
2	do	Mars	1896	14,900	17.7	1,850	1896	
3	do	Hannibal	1896	14,900	18.0	1,850	1898	
4	do	Resolution	1892	14,150	17.9	1,800	1893	
5	do	Magnificent (flagship)	1894	14,900	17.6	1,850	1895	
6	do	Prince George	1896	14,900	18.3	1,850	1896	
7	do	Jupiter	1895	14,900	18.4	1,850	1897	
8	do	Repulse	1892	14,150	18.2	1,800	1894	Ran aground in river; at dockyard from July 12 to 22.
	CRUISERS.							
1	Armored cruiser	Narcissus	1886	5,600	18.5	750 to 900	1901	
2	do	Immortalite	1887	5,600	19.0	900	1901	
3	Cruiser, first class	Diadem	1896	11,000	20.8	1,000	1898	
4	do	Niobe	1897	11,000	20.5	1,000	1898	
5	do	Hawke	1891	7,350	19.8	850	a 1901	
6	do	Furious	1896	5,750	20.1	500	1898	
7	Cruiser, second class	Arrogant	1896	5,750	19.6	500	1898	Receiving new feed pumps; did not join fleet until July 24.
8	do	Mersey	1885	4,050	18.0	900	a 1901	Ran aground leaving Sheerness; got off two hours later without injury.
9	do	Rainbow	1891	3,600	20.2	400	a 1901	
10	do	Retribution	1891	3,600	20.3	400	a 1901	Accident to feed pumps.
11	Cruiser, third class	Pelorus	1896	2,135	20.7	250	1897	Delayed joining the fleet until July 29, because of repairs to machinery
12	do	Pactolus	1896	2,135	20.5	250	1899	
13	Torpedo gunboat	Gleaner	1890	735	20.1	100	(?)	

DESTROYERS.									
1	Topedo boat destroyer.....	Leven	1898	308	30.0	± 80	(b)	Accident to feed pumps.	
2	do.....	Locust.....	1896	360	31.0	± 80	(b)		
3	do.....	Thorn	1900	305	30.0	± 80	a 1901		
4	do.....	Vigilant.....	1900	305	30.0	± 80	a 1901		
5	do.....	Leopard	1897	330	30.0	± 80	(b)	Owing to accident to machinery, collided with a collier; dockyard for repairs. Injuries to boilers.	
6	do.....	Gypsy	1897	340	30.2	± 80	(b)		
7	do.....	Tiger	1900	305	30.0	± 80	a 1901		
8	do.....	Osprey	1897	340	30.3	± 80	(b)		

Y SQUADRON.

(Base: Scilly Isles.)

1	Cruiser, second class	Brilliant.....	1891	3,600	20.4	400	a 1901	Bent propeller blade; replaced propeller. Injuries to machinery, several days at dockyard.	
2	do.....	Aeolus.....	1891	3,600	19.5	400	a 1901		
3	Torpedo gunboat.....	Sharpshooter.....	1888	735	19.0	100	a 1901		
4	do.....	Jason.....	1892	810	19.3	100	(?)		
5	Torpedo depot ship	Hecla	1878	6,400	13.0	2,200	a 1901	Bent propeller blade; replaced propeller. Injuries to machinery, several days at dockyard.	
6	Torpedo boat destroyer	Lee.....	1899	335	30.1	± 80	(b)		
7	do.....	Cynthia	1898	310	30.2	± 80	(b)		
8	do.....	Sturgeon	1894	270	27.2	± 80	a 1901		
9	do.....	Desperate	1896	310	30.4	± 80	(b)	Insignificant repairs.	
10	do.....	Angler	1897	310	30.4	80	a 1901		
11	do.....	Salmon	1895	280	27.9	60	a 1901		
12	do.....	Mallard	1896	310	30.1	80	(b)		
13	Torpedo boat, first class	58.....	1886	60	21.0	20	a 1901	Insignificant repairs.	
14	do.....	66.....	1886	75	19.2	20	a 1901		
15	do.....	76.....	1886	75	19.2	20	a 1901		
16	do.....	98.....	1901	150	25.6	(?)	a 1901		

a July 16, 1901.

b Instruction flotilla.

X Fleet—Continued.**Z SQUADRON.**

(Base: Channel Isles).

	Class.	Name.	Launched.	Displace- ment.	Speed.	Coal.	Commis- sioned.	Accidents during maneuvers.
				<i>Tons.</i>	<i>Knots.</i>	<i>Tons.</i>		
1	Cruiser, second class	Thames	1886	4,050	18.0	900	a 1901	Served as torpedo depot ship.
2	do	Iris	1877	3,730	17.0	780	a 1901	
3	do	Iphigenia	1891	3,600	20.0	400	a 1901	
4	do	Intrepid	1891	3,600	20.1	400	a 1901	
5	Torpedo gunboat	Seagull	1889	735	19.2	100	a 1901	
6	do	Sheldrake	1889	735	19.2	100	a 1901	
7	Destroyer	Mernaid	1898	335	30.8	80	(b)	
8	do	Zebra	1895	310	27.0	60	a 1901	Slight injury to machinery.
9	do	Avon	1896	330	30.3	± 80	a 1901	
10	do	Bittern	1897	330	30.2	± 80	a 1901	
11	do	Spitfire	1895	295	27.1	60	a 1901	
12	do	Albatross	1898	360	32.0	80	a 1901	
13	do	Snapper	1895	280	27.9	60	(b)	Do.
14	do	Haughty	1895	290	27.1	60	(b)	
15	do	Porcupine	1895	280	27.0	74	(b)	
16	do	Ariel	1897	310	30.6	80	a 1901	
17	do	Contest	1894	295	28.0	60	a 1901	
18	do	Dasher	1894	250	27.0	60	a 1901	
19	Torpedo boat, first class	58	1886	60	21.0	20	a 1901	
20	do	79	1886	75	19.2	20	a 1901	
21	do	81	1885	125	20.8	35	a 1901	
22	do	82	1885	85	23.0	20	a 1901	Stranded on Alderney Mole Aug. 1.
23	do	85	1885	85	23.0	20	a 1901	
24	do	86	1889	85	23.0	20	a 1901	

SUBJECT TO THE ORDERS OF THE CHIEF OF STATION AT QUEENSTOWN.

1	Gunboat, first class.....	Curlew	1885	950	15.0	250	^a 1901		
2	Survey ship.....	Seahorse.....	1880	670	12.6	135	(?)		
3	Steamer.....	Stormcock.....	.....	.....	.....	.....	(?)		

^a July 16, 1901.^b Instruction flotilla.*B FLEET.*

[Rear-Admiral Sir C. Noel; Rear-Admiral H. L. Grenfell.]

MAIN FLEET.

	Class.	Name.	Launched.	Displacement.	Speed.	Coal.	Commissioned.	Accidents during maneuvers.
	BATTLESHIPS.			Tons.	Knots.	Tons.		
1	Battleship, first class	Revenge (flagship)....	1892	14,150	17.5	900	1901	
2	do.....	Collingwood	1882	9,500	16.5	900	1897	
3	do.....	Beulow	1885	10,600	17.5	900	1894	
4	do.....	Anson	1886	10,600	17.5	900	1901	
5	do.....	Sans Pareil (flagship)....	1887	10,470	17.5	900	1895	
6	do.....	Nile	1888	11,940	17	900	1898	
7	do.....	Trafalgar.....	1887	11,940	17.3	900	1897	
8	do.....	Camperdown.....	1885	10,600	17.1	900	(?)	
9	do.....	Howe.....	1885	10,300	17	900	1897	
10	do.....	Colossus.....	1882	9,420	15.4	970	1893	
11	do.....	Dreadnought.....	{ 1875 1898	{ 10,820 9,420	13.5	1,200	^a 1901	
12	do.....	Edinburgh	1882	9,420	15	970	^a 1901	
	CRUISERS.							
1	Cruiser, first class.....	Amphitrite.....	1898	11,000	20.5	1,000	^a 1901	
2	do.....	Ariadne	1898	11,000	21.2	1,000	^a 1901	

Slight injuries to machinery.

Immediately after being placed in commission had to be docked to have bottom cleaned; could only make 9 knots.

^b Instruction flotilla.^a July 16, 1901.

B FLEET—Continued.

MAIN FLEET—Continued.

Class.	Name.	Launched.	Displacement.	Speed.	Coal.	Commiss- ioned.	Accidents during maneuvers.
CRUISERS—continued.			<i>Tons.</i>	<i>Knots.</i>	<i>Tons.</i>		
3 Cruiser, first class	Edgar	1890	7,350	20.5	850	α 1901	Docked after being put in commission; same as above. Injuries to port engines; loss of 1 anchor.
4 Armored cruiser	Galatea.....	1887	5,600	19	900	1893	
5 do	Impérieuse	1883	8,400	17	900	α 1901	
6 Cruiser, second class.....	Minerva.....	1895	5,600	20.3	550	1899	Slight injuries to machinery, and leaky boilers, soon after being commissioned.
7 do	Hyacinth.....	1898	5,600	20.5	550	1900	
8 do	Forth.....	1886	4,050	18	500	α 1901	
9 do	Andromache	1890	3,400	20.1	400	1901	Leaky steam pipe; at dockyard from July 25 to 27.
10 do	Apollo.....	1890	3,400	20.3	400	1901	
11 Cruiser, third class	Pandora.....	1900	2,215	20	250	α 1901	
12 Cruiser, second class.....	Latona	1890	3,400	20.1	400	α 1901	Leaky steam pipe; at dockyard from July 25 to 27.
13 do	Fox	1893	4,360	19.9	400	α 1901	
14 Torpedo gunboat.....	Onyx.....	1892	810	19.1	100	1901	
DESTROYERS.							
1 Torpedo-boat destroyer.....	Petrel	1900	325	31	±80	(<i>b</i>)	Ran aground at Portsmouth; in consequence, placed out of commission.
2 do	Kestrel	1898	335	30	80	(<i>b</i>)	
3 do	Chamois.....	1896	360	30.1	85	α 1901	
4 do	Recruit.....	1896	355	30	80	α 1901	Leaky condensers; dockyard for repairs.
5 do	Crane	1896	360	30.3	85	(<i>b</i>)	
6 do	Vulture	1898	355	30	80	(<i>b</i>)	
7 do	Fawn.....	1897	360	30.5	85	α 1901	Leaky condensers; dockyard for repairs.
8 do	Myrmidon.....	1900	325	31	80	α 1901	

a July 16, 1901.

b Instruction flotilla.

C SQUADRON.

(Base: Plymouth.)

1	Cruiser, second class	Spartan	1890	3,600	20.4	400	α 1901	Foul bottom; cleaned by divers.
2	do.....	Sirius.....	1890	3,600	20.3	400	α 1901	Do.
3	Torpedo gunboat.....	Skipjack	1889	735	19	100	(?)	
4	do.....	Renard	1893	810	19	100	(?)	
5	Destroyer.....	Bat.....	1896	360	30.1	85	(b)	
6	do.....	Fairy.....	1897	340	30.2	80	(b)	
7	do.....	Shark	1894	280	27.6	60	α 1901	Collided with Zephyr.
8	do.....	Opossum	1895	295	27.2	60	α 1901	
9	do.....	Wolf.....	1897	360	30.3	80	(b)	
10	do.....	Panther.....	1897	360	30.1	80	(b)	
11	do.....	Fervent	1895	280	27	60	α 1901	Placed out of commission in consequence of injuries to machinery.
12	do.....	Decoy	1894	260	27.8	50	α 1901	
13	do.....	Zephyr	1895	280	27	60	α 1901	Collided with Shark; side pierced.

 α July 16, 1901.

D SQUADRON.

(Bases: Portland, Portsmouth.)

1	Cruiser, second class	Melampus	1890	3,400	19.8	400	1893	
2	do.....	Mercury.....	1878	3,730	17	780	α 1901	
3	Torpedo gunboat.....	Prometheus	1898	2,135	20.8	250	α 1001	Injuries to engines; several days at dockyard for repairs.
4	do.....	Severn	1895	4,050	18	500	1899	
5	Destroyer.....	Scylla	1891	3,400	20.3	400	α 1901	
6	do.....	Leda	1892	800	18.3	100	1893	
7	do.....	Speedwell	1889	735	19	100	(?)	
8	do.....	Spiteful	1900	360	30	$\pm$ 80	(b)	
9	do.....	Starfish	1895	270	28	60	α 1901	On August 2 stranded on rock off Casquettes; no loss of life.
10	do.....	Viper.....	1899	325	31	$\pm$ 80	α 1901	

B FLEET—Continued.

D SQUADRON—Continued.

Class.	Name.	Launched.	Displacement.	Speed.	Coal.	Commissioned.	Accidents during maneuvers.
			Tons.	Knots.	Tons.		
11 Destroyer.....	Havock	1893	240	26.8	50	a 1901	
12 do.....	Brazen	1896	355	30	80	(b)	
13 do.....	Kangaroo	1900	305	30	±80	a 1901	Steering gear broken.
14 do.....	Wizard	1895	270	27.2	60	a 1901	
15 do.....	Violet	1897	355	30.2	±80	a 1901	Injuries to boilers; split tube.
16 do.....	Electra	1896	355	30	80	(b)	
17 do.....	Teazer	1895	270	27.1	60	a 1901	Slight injuries to engines.
18 do.....	Surly	1894	280	27.4	60	1901	
19 do.....	Sylvia	1897	335	30.1	80	(b)	Do.
20 do.....	Hunter	1895	275	27.9	60	a 1901	
21 do.....	Charger	1894	250	27.9	60	a 1901	
22 do.....	Bullfinch.....	1898	340	30	80	a 1901	

a July 16, 1901.

b Instruction flotilla.

SUBJECT TO ORDERS OF CHIEF OF STATION AT PLYMOUTH.

Class.	Name.	Launched.	Displacement.	Speed.	Coal.	Commissioned.	Accidents during maneuvers.
			Tons.	Knots.	Tons.		
Torpedo gunboat.....	Antelope	1893	810	19	100	(?)	
Special ship	Traveler.....	1893	700	13	140	(?)	
Gunboat, third class.....	Tay.....	1876	363	9	55	a 1901	
Torpedo boat, first class.....	45.....	1886	60	21	20	a 1901	
.....do.....	52.....	1886	60	21	20	a 1901	
.....do.....	53.....	1886	60	21	20	a 1901	
.....do.....	54.....	1886	60	21	12	a 1901	

a July 16, 1901.

b Instruction flotilla.

B—SUBJECT TO THE ORDERS OF THE CHIEF OF STATION AT PORTSMOUTH.

AT PORTLAND.

1	Torpedo gunboat.....	Spanker ^a	1888	735	19	100	1901
2	Gunboat, third class.....	Spey ^a	1876	363	19	55	b 1901
3	Torpedo boat, first class	26.....	1886	60	21	10	b 1901
4	do	27.....	1886	60	21	10	b 1901

AT PORTSMOUTH.

1	Torpedo gunboat	Circe	1892	810	19.3	100	1901	Slight injuries to machinery.
2	Special ship	Magnet ^a	1883	430	12.3	90	(?)	
3	Gunboat, second class.....	Raven ^a	1882	465	9.7	40	(?)	
4	Gunboat, first class	Landrail ^a	1886	950	15	250	b 1901	
5	Gunboat, third class.....	Trent ^a	1877	363	9	55	b 1901	
6	Torpedo boat, first class....	41.....	1886	60	21	20	b 1901	
7	do	42.....	1886	60	21	20	b 1901	
8	do	49.....	1886	60	21	20	b 1901	
9	do	50.....	1886	60	21	20	b 1901	

^a Harbor watch duty.

b July 16, 1901.

SECTION II.

FRANCE.

The French naval maneuvers of 1901 involved for the first time a phase of offensive action (offensive in execution, defensive in its object) on the part of the French fleet.

Four squadrons, combined two and two, were employed. The squadrons representing the French forces were designated as Squadrons A and A¹, while the enemy's squadrons were designated by B and C.

The designation of these squadrons was a subject of interesting comment. A and A¹ were evidently two elements of one nation, while the designation B and C, of the two squadrons of the enemy, was held to signify that they were allied forces of two powers, and were not two elements of the naval force of one power, for in this case the squadrons would naturally have been designated by B and B¹ instead of by B and C.

Some held that the operations represented war with England, in which the English Channel Squadron was B and the Mediterranean Squadron at Malta was C. This, it was contended by some, was a false analysis, because of the squadrons being designated B and C instead of B and B¹.

By others the operations simulated a war with the Triple Alliance, in which C represented the Italian forces, B the German fleet, and A and A¹, respectively, the French Mediterranean and Northern squadrons.

The probability is that the latter conception is more correct than the former, although each case is one of conjecture, as no definite information was given out, and naturally so, by the French authorities.

No exercise in mobilization took place, the lack of personnel, and the element of expense probably preventing. In place of this, Vice-Admiral Fournier made a tour of the north coast during the maneuvers and inspected the mobile defenses there, at which time the torpedo boats of Category A were made mobile and took part in the exercises, apparently for the purpose of showing that, even during the absence, of the North Squadron these coasts were not without defense.

The direction of the maneuvers was assigned to Vice-Admiral Gervais, who was also made commander in chief of all the naval forces assembled for these exercises—the North Squadron, the Mediterra-

nean Squadron, and the mobile defenses of the south coast of France, Corsica, Algiers, and Tunis.

Out of the reserve there were placed in commission for the maneuvers the battleship *Brennus* for the Mediterranean Squadron (according to a report with only half the crew allotted by the budget), which took the place of the *Bouvet*, selected for flagship, and the cruiser *Lavoissier*, with the transport *Japon* (as collier). The cruiser *Condor* was brought from Crete and added to the squadron. Of the division of armored coast-defense vessels of the North Squadron, only the *Bouvines* and the *Amiral Tréhouart* could take part in the exercises, making up their crews from the two remaining armored coast-defense ships *Balmy* and *Jemmapes*, which were placed in the reserve, second category. Two steam colliers with about 1,600 and 1,400 tons of coal, respectively, were chartered to accompany the North Squadron.

Officers of the Naval Academy were embarked in the fleet.

Twenty-five men were taken from the reserves for each battleship and ten for each cruiser.

The torpedo-depot ship *Foudre* had on board a captive balloon, with crew.

GENERAL IDEA OF THE MANEUVERS.

France finds herself at war with an eastern and a western power. The French Northern Squadron (A¹) is on its way to reenforce the Mediterranean Squadron (A). Squadron B of the western power is about to enter the Strait of Gibraltar to join Squadron C of the eastern power, which is lying in one of the principal ports of this power.

Squadron A is in possession of the coasts of Algeria and France.

Squadrons B and C are masters of the coasts of Tunis and Corsica.

The coasts of Spain, Balearic Isles, and Sardinia are considered neutral.

The following places are considered fortified to some degree, but are unable to hold out against an attack by a heavily armed squadron:

In Algiers—Oran.

Philippeville.

Tabarca.

In France—Marseilles.

Port Vendres.

Island of Hyères.

Villefranche.

In Corsica—St. Florent.

Bonifacio.

The following places are considered as impregnable:

In France: Toulon.

In Algieria: Algiers.

In Corsica: Ajaccio. (Reports contradictory as to impregnability.)

Squadrons A and A¹ are supported by—

1. The mobile defense of Algeria.
2. The mobile defense of Tunisia (transferred to Algiers).
3. The mobile defense of Toulon.

Squadrons B and C are supported by the mobile defenses of Corsica.

The object of the maneuvers was twofold—one phase strategical, the other tactical.

After the first phase, all ships were combined, under the command of Admiral Gervais, for tactical exercises, one object being to develop certain tactical formations.

The strategic phase is first considered:

A is stronger than either B or C, but not as strong as B and C united.

In the strategic phase A is to try to prevent B joining C and to destroy B at the beginning of hostilities. If unsuccessful in this, B and C, joined, gave chase to A, who sought to join A¹, and A and A¹, united, in turn gave chase to B and C combined, in order to destroy them.

B is to join C, the latter under B's command is lying at Ajaccio, and can not leave this port until it has been ordered so to do by B.

RULES AND REGULATIONS OBSERVED DURING THE MANEUVERS.

The gun.

1. To each ship is assigned a number corresponding to its military or fighting value, which in order of battle (*ordre de bataille*) is to be displayed below and after the name of the ship.

2. As soon as the hostile forces face each other, each vessel is to signal her fighting strength, and, when at a distance of 5,000 meters, begin firing.

3. In order that the engagement may have a result, the stronger party must maintain the weaker under fire for at least twenty minutes at a distance less than 5,000 meters (5,450 yards), or else ten minutes at a distance less than 3,000 meters (3,270 yards), or again cross him at a distance of less than 1,500 meters (1,635 yards).

4. At night all distances are to be reduced by one-half.

5. The engagement being at an end, the *admiralissimo* is to decide to what extent both adversaries are weakened, or which one of them is destroyed, as follows:

(a) If the combatants are equally strong, each loses one-fourth of its military value.

(b) If the military value of one combatant is greater than two-thirds of the other, the stronger loses a quarter of the military value of the weaker and the weaker loses a third of the value of the stronger.

(c) If, on the other hand, the military value of one is less than two-thirds of the value of the other combatant, the weaker is destroyed, and the stronger loses a third of the military value of the weaker.

6. During engagements a strict account of ammunition is to be kept, and should a vessel exhaust her supply she loses all military value for twenty-four hours, during which time she is supposed to replenish her magazines.

The torpedo.

7. For a vessel to be judged as being successfully torpedoed, the attacking party must launch its torpedo or torpedoes at a distance not greater than 400 meters (436 yards) and at an angle of at least 30 degrees with the keel line of the vessel attacked.

8. A torpedo boat remaining under a searchlight for ten minutes, before being able to launch her torpedoes, is to be considered destroyed.

9. Any vessel successfully torpedoed shall lose military value as follows:

A battleship, one-fourth its value.

A first or second class cruiser, one-third.

A third-class cruiser, one-half.

10. Each destroyed vessel is to remain neutral for twenty-four hours, and under the proper signal sails for the nearest friendly port, where she will find instructions prepared in advance. She is then restored to her full military value and is to rejoin her friends and continue to participate in the operations.

11. A torpedo boat having fired all her torpedoes is to remain neutral for twenty-four hours under provisions similar to those of section 9.

Attacks against coasts.

12. All enterprises against hostile coasts permitted by international law are allowed.

13. Secondary positions relatively armed, belonging to combination A or B, are considered as destroyed under the following conditions:

(a) After a six-hours engagement with an armed squadron having a military value greater than 300.

(b) After a three-hours engagement with a squadron having a military value greater than 600.

14. Forces attacking shore stations lose 20 units for each hour's duration of the fighting.

15. Semaphore stations may be destroyed by the attacking party standing for thirty minutes at a distance not greater than 3,500 meters (3,815 yards).

16. From the moment of destruction, semaphores may no longer signal vessels of their side.

17. Neither side is to go beyond the limits of maneuver area.

18. All means of obtaining information concerning the enemy are permitted. French consuls, in Spain, are requested to forward telegrams and information concerning the enemy.

19. Coast guard and signal stations are garrisoned and take part in the maneuvers.

UMPIRING.

Admiral Gervais, who was the supreme judge of the maneuvers, was on board the *Bouvet*, escorted by the *Galilée* and *Hellebarde*.

These vessels were neutral in principle; nevertheless the admiral reserved the right to interfere in favor of one or the other of the squadrons by putting ships out of action or by reducing their fighting strength to indicate their reduced power through injury in action, in order to reestablish the balance.

The object of this was to prevent a too sudden and unexpected termination of the maneuvers, without an opportunity to draw the necessary lessons.

Composition of the squadrons.

A.—VICE-ADMIRAL DE MAIGRET IN COMMAND.

No.	Class.	Name.	Fighting value.	Tonnage.	Launched.	Speed.	Coal, normal.
1	First-class battleship...	Saint Louis.....	250	11,275	1896	18	820
2	do	Charlemagne.....	250	11,275	1895	18	680
3	do	Gaulois.....	250	11,275	1896	18	680
4	do	Brennus.....	250	11,395	1891	17	800
5	Armored cruiser.....	Pothuan.....	50	5,360	1895	19	535
6	do	Chanzy.....	50	4,933	1894	19	413
7	do	Latouch-Tréville.....	50	4,756	1892	18	406
8	Second-class cruiser....	Cassard.....	25	3,952	1896	19.8	630
9	do	Du Chayla.....	25	3,952	1895	20	624
10	Torpedo transport.....	Foudre.....	20	6,090	1895	19.9	840
11	Third-class cruiser.....	Linois.....	20	2,345	1894	20.5	200
12	Torpedo cruiser.....	Condor.....	10	1,243	1896	17.7	160
Total fighting value.....			1,250	.....	.....	.....	.....

A.¹—REAR-ADMIRAL MALLARMÉ.

1	Third-class battleship..	Tréhouart.....	150	6,629	1893	15.7	300
2	do	Bouvines.....	150	6,610	1892	16	300
3	Torpedo gunboat.....	La Hire.....	5	896	1898	23	128
4	Collier.....	Japon.....	.....	.....	.....	.....	.....
Total fighting value.....			305	.....	.....	.....	.....

B.—VICE-ADMIRAL MÉNARD IN COMMAND.

1	First-class battleship...	Masséna.....	150	11,924	1895	17	630
2	do	Carnot.....	150	12,008	1894	17.8	705
3	do	Hoche.....	125	10,997	{1886} {1900}	16	800
4	do	Amiral Baudin.....	125	11,911	{1883} {1899}	15	800
5	do	Formidable.....	125	12,165	{1885} {1899}	16	900
6	Second-class battleship.	Courbet.....	125	10,808	{1881} {1899}	15.4	1 000

*Composition of the squadrons—Continued.***B.—VICE-ADMIRAL MÉNARD IN COMMAND—Continued.**

No.	Class.	Name.	Fighting value.	Tonnage.	Launched.	Speed.	Coal, normal.
7	Armored cruiser.....	Bruix.....	50	4,754	1894	18	406
8	do.....	Dupuy de Lôme.....	50	6,406	1890	20	900
9	Second-class cruiser.....	D'Assas.....	25	4,000	1896	19	630
10	Third-class cruiser.....	Surcouf.....	15	2,044	1888	20.5	200
11	Torpedo gunboat.....	Cassini.....	10	958	1894	21.2	110
	Total fighting value.....	.....	950	.....	.....	.....	.....

C.—REAR-ADMIRAL AUBRY DE LA NOE.

1	First-class battleship...	Charles Martel.....	200	11,880	1893	18	677
2	do.....	Jauréguiberry.....	200	11,824	1893	18	700
3	Third-class cruiser.....	Lavoisier.....	20	2,317	1897	20	226
4	Torpedo gunboat.....	Dunois.....	5	896	1897	23	137
	Total fighting value.....	.....	425	.....	.....	.....	.....

GENERAL OUTLINE OF OPERATIONS.

Maneuvers began on July 3, when A squadron, which had come westward from Algiers, heard that B had passed the Straits of Gibraltar. A thereupon proceeded at full speed toward him, and discovering first B's cruisers defeated them. This crippled B, whose battle squadron was reported as standing up the coast of Spain, attempting to avoid A by standing northeast close to the coast. A immediately followed at full speed on a course which, owing to the direction of the coast, would have compelled B to approach A on a converging course. The B admiral altered course to the south, with the hope of gaining time and enabling the C squadron to join him. He was, however, taken at a disadvantage and defeated.

Admiral Gervais, having arrived on the scene on the *Bouvet*, took command of both fleets and redispersed of the squadrons.

Not desiring this termination of the maneuvers, Admiral Gervais decreed that the engagement had resulted in the escape of B, but that both sides had had their fighting value reduced by the damages sustained in action. He directed A to proceed toward Oran and B to go eastward, so that the operations might be resumed.

It is to be noted, however, that this disposition allowed B and C to unite.

A proceeded toward Oran and was joined by A¹. The battleships of A and A¹ proceeded toward Mers el Keber, while the cruisers were sent to keep touch with the enemy.

B and C proceeded to Ajaccio, and were followed later by A and A¹, who established a blockade at Ajaccio.

B and C later came out and an action was fought, resulting in the

defeat of A and A¹. From this point the narrative is taken from the *Marine Rundschau*.

DETAILS OF THE MANEUVERS.

Squadron A received from its dispatch boat at noon on July 3 the information that B had passed through the Straits of Gibraltar at 8 a. m. A sent the cruisers *Foudre* and *Linois* eastward to observe the movements of C, and itself started for Cape Palos at a speed of 13 knots, while the main body remained on the Spanish coast and the cruisers made scouting trips to the south; the surveillance of the passage between Oran and Alboran was assigned to the mobile defenses of Algiers and Tunis. On the morning of the 4th, at 3 o'clock, *Du Chayla* sighted the hostile cruisers *Brux*, *Dupuy de Lome*, and *D'Assas*, and fled before them back to A, avoiding the scouts of her own squadron. The cruisers of squadron B, which had passed the meridian of Tarifa at 8 a. m., and was steering close along the Spanish coast toward the rendezvous appointed for C off Cape Cullera, followed the *Du Chayla* and suddenly found themselves illumined by the searchlights and under fire from the main body of the enemy, which soon put them *hors de combat*. They sailed for Alicante for the 24 hours' exclusion from the maneuvers. Soon after this the destroyer *Espignole*, which had been dispatched to the Bay of Alicante, there discovered B close under the high land steering to the east, and also the commander of the fleet. B sought to escape from battle, but was forced to fight by A, and defeated, so that the principal problem was settled by A. The commander in chief broke off the maneuvers.

Meanwhile, where was C? The latter evidently did not receive notice of the passing of the Straits of Gibraltar by B until the 4th, for at 6 a. m. of the 4th it started for the rendezvous. While weighing anchor the *Charles Martel* was struck by a torpedo from the submarine *Gustave Zédé*, which had come from Toulon in company with a tug. The distance of Ajaccio from the rendezvous, 450 miles, did not permit C to arrive in time. The same cause prevented the cruisers *Foudre* and *Linois*, sent out to observe C, from being at Ajaccio before the sailing of the same. These two cruisers formed for the rest of the time an invisible scouting group, which did not again appear until July 8, off Marseille, and was sent from there to Villefranche, where the seagoing torpedo boats of squadron A had in the meantime arrived after a stormy passage. It was not at any time able to prevent the attacks of the Corsican torpedo boats against the coast guard stationed along the French coasts, which resulted in a mobilization at Toulon on the 6th.

DISCUSSION OF THE PRECEDING EVENTS.

As Squadron C, in consequence of its composition and strength, was not in a position to undertake serious enterprises against the French

coast, Admiral de Maigret, in order to accomplish his principal task—namely, to prevent the union of B and C—was able, by leaving a scouting group to observe C; to go to meet B the more promptly, as at the beginning of hostilities he was just as near the Straits as Ajaccio. The only question for him was whether B would shape his course to the north or to the south of the Balearic Islands. It was too late for him to waylay B in the straits between Oran and the Spanish coast; this must be left to the mobile defenses of Oran and Algiers. It was to be supposed that B, in the passage through the straits, would keep close to the Spanish coast and follow the latter as far as Cartagena, whether he then sought to join C by course to the north or to the south of the Balearic Islands. Admiral de Maigret acted correctly in proceeding between the Balearic Islands and Cape St. Antonio along the Spanish coast to the south. In this way he could intersect the hostile squadron before it left the Spanish coast in case he chose the course to the south of the Balearic Islands. The number of his cruisers was not sufficient to find the enemy in the wide sea room south of the Balearic Islands.

Admiral Ménard with Squadron B desired to accomplish the union with C by a course to the north of the Balearic Islands, and was therefore obliged to keep to the Spanish coast. He may have been influenced to this decision by the possibility of keeping himself in communication with C by using the telegraph of the neutral State; his chances of success would seem greater if he had taken the route between the Balearic Islands and the African coast and had located the rendezvous at about halfway between Tarifa and Ajaccio. He had far better chances of remaining undiscovered in the open space than in confined waters.

Some newspaper reports state that Admiral de Maigret intercepted a dispatch sent by A by wireless telegraphy, which reported the rendezvous for B and C, and took measures accordingly. This was possibly an interference on the part of the commander in chief; for if B took his course to the north of the Balearic Islands while A was searching to the south, the whole maneuvers must have passed without any result. The mobile defenses of Oran and Algiers were unsuitable, both in number and in general, for guarding the straits, as besides the torpedo boats only three division boats were present. This was known to the commander in chief, and no attempts of any kind were to be made here, which above all things should have been the purpose of the maneuvers. This was only possible when the combatants could really meet, and to that end the run along the Spanish coast was the better suited, especially as the opportunity was thus offered to gather experience as to the transmission of information by the aid of the French consuls.

The way scouting was managed is not clearly seen; in any case the few scouts of the two squadrons were on duty. *Condor*, of Squadron

A, could not at any time maintain the speed. That the scouting group from B followed the *Du Chayla* and lost touch with the main body is said to have been due to the misunderstanding of an order. According to a newspaper report this order was to decoy the hostile scouts southward—that is, away from B—and awaken the belief that Squadron B was shaping his course south of the Balearic Islands. If Admiral Ménard had really contemplated this deception of the enemy, his cruisers would have done exactly the opposite. In any case it was a mistaken line of action, which was avenged on B. If this squadron had received news of the enemy in time, it would perhaps have been able to escape from him, as the speed of A was very unfavorably influenced by the slowly moving *Brennus*.

Details as to the battle in the bay of Alicante are lacking. It appears, however, that B was outmaneuvered by A and hemmed in between A and the coast, so that it could not avoid fighting.

The scouting group from A, sent out to watch C, in no respect fulfilled its mission, although it must have met C. The *Charles Martel* was, moreover, not weakened as to fighting strength by the torpedo from the *Gustave Zédé*, the judge basing this decision upon the grounds that the port of Ajaccio, being inaccessible to the enemy, was also inaccessible to submarines. The mobile defenses of Oran and Algiers had reconnoitered for the enemy in vain.

The director of the maneuvers, Admiral Gervais, was present when the decisive encounter took place.

CONTINUANCE OF THE STRATEGIC MANEUVERS.

The commander in chief at noon of the 4th ordered a cessation of the maneuvers. This interval he used for evolutions of the fleet as a whole, and then made new dispositions, as follows: Squadron B had succeeded in escaping destruction by the enemy. Its cruisers which had been placed *hors de combat* were restored to it, and it was permitted to go out of sight of A. Both squadrons had suffered damage in the battle; reenforcements for both were on the way; C had left Ajaccio on July 4 at 6 a. m., and A¹ Cadiz at 4 p. m. The new maneuvers were to begin at 3 a. m. July 5. The problem for both parties remained unchanged.

A sent some cruisers to meet Division A¹, expected from Cadiz, and lay over night in the vicinity of the Bay of Alicante. B went to meet C and joined the latter near the Balearic Islands on the morning of the 5th. Both squadrons were now superior to A and proceeded against the latter, who sighted their cruisers in the neighborhood of Alicante and retreated before them in a southerly direction at a speed of 13 knots. A higher speed seemed impossible on account of the imperfect action of the engines of the *Brennus*. The cruisers kept touch and the chase continued the whole day without result. Toward

evening the cruisers of Squadron A sent to meet Division A¹ came in sight to the west; B and C gave up the unpromising chase and proceeded toward Ajaccio, where they arrived at 4 a. m. on the 8th. A and A¹ were quite close to Mars-el-Kebir, where they met on the night of the 5th. As A¹ had to replenish her coal before further operations, as must also various cruisers, Admiral de Maigret anchored in the roads. He here received telegraphic notice of the entrance of the two hostile squadrons into Ajaccio, and after filling his bunkers from the transport *Japon* set out for Ajaccio at noon of the 6th, leaving behind the *Espignole* with a bent piston rod. The sea became so rough on the way that the *Condor* had to remain behind and the squadron proceeded at a speed of only 12 knots. On July 8, at 6 p. m., A and A¹ undertook the blockade of Ajaccio, and the *Foudre*, with the torpedo boats of the mobile defenses of Toulon, also joined them.

DISCUSSION OF THE PRECEDING EVENTS.

After Squadron B had withdrawn from the battle with A, the next thing for A would have been to follow B. The chances against this were that before B could be overtaken it would have joined C, and would then have been superior to A. Moreover, it had become necessary for certain cruisers to replenish their coal supply, which was also necessary for Division A¹ before undertaking further operations.

These causes probably led Admiral de Maigret to give up the pursuit of B, and to send three of his cruisers to Division A¹ with instructions to order it to Oran.

The chase begun on the 5th could not, from the beginning, have any prospect of success, on account of the speed conditions of both squadrons. The distance of the two main bodies was too great—one report gives 50 miles, though it was probably about 20 miles—and the superiority of speed of B and C, 2 knots at the highest speed, which, moreover, could not be steadily maintained, was too small. It gave an opportunity to the ships concerned to practice in a sustained run at high speed, which, according to all reports, succeeded very well. It also proved the strategic value of speed. The giving up of the chase when Division A¹ was thought to be sighted was proposed in order to insure a retreat from the probable pursuit, and also the return to Ajaccio, whereby time was secured for coaling.

THE BLOCKADE OF AJACCIO.

Ajaccio as principal port for B and C being impregnable to A, A immediately after its arrival sent a landing company ashore, which broke up the observation station on the Sanguinaires and caused the passage between the islands and Corsica to be closed to hostile torpedo boats by obstructions, and searched the north and south coasts of the bay for torpedo boats, during which a division was pursued and some

boats placed hors de combat. The blockade was maintained in four lines, the inner consisting of torpedo boats and torpedo-boat destroyers, the second of cruisers, the third of armored cruisers, and the fourth, the outer, of battleships. All ships kept under way with masked lights. The blockaded sought to injure the enemy by means of its torpedo boats, but these attacks were no more successful than those of the blockading torpedo boats. The attacks were made separately by groups and did not go beyond the inner lines.

By direction of the commander in chief, Admiral Ménard, with squadrons B and C, went out from Ajaccio against the enemy on the morning of July 9, with the following results:

THE BATTLE OFF AJACCIO.

(See plate II.^a)

The battleships of A and A¹, under Admiral de Maigret, were steaming at slow speed, line ahead, in a northerly course toward land, the end division being at a great distance, when at about 4 o'clock on the morning of the 10th the battleship squadrons B and C, under Vice-Admiral Ménard, also in line ahead, were discovered steering toward A's leader in a westerly course (position 1, plate II), at about 4,500 meters distance. Immediately thereafter they opened fire and turned 90° to port (position 2, plate II); that is, on the opposite course to A A¹. A and A¹ returned fire. Admiral de Maigret gave the signal, by simultaneously turning 16 points, to make the former end ship the leader,^b according to other reports, by turning 120° to port. This signal appears not to have been understood by all the ships; at any rate, it was only partly obeyed, so that Admiral de Maigret gave the signal to stop. Most of the ships had by this time turned 8 points to port; Admiral Ménard (B and C) had meanwhile swung round to a position 8 points to port of the end ship, position 3, and could hold the enemy, thrown into disorder, under a destructive fire without the latter being able to return it; as his own end ships masked the guns of the others. Admiral de Maigret (A A¹) then signaled, "Follow the leader," and advanced in a course parallel to B and C. But it was too late; his end ships were destroyed. The judge closed the battle and declared the squadron of de Maigret vanquished.

DISCUSSION OF THE BATTLE.

Squadrons A and A¹ seemed to have been taken entirely by surprise by the appearance of B and C; the cruisers were farther within the bay, and the slight fog may have enabled B and C to go out unnoticed

^aThe sketch can make no claim to accuracy regarding the position of the ships in the Bay of Ajaccio, as data relative to the portion of the bay occupied by A A¹ is lacking.

^bChanger l'ordre de tête-à-queue par un mouvement tous à la fois.



Plate II.

Fitting-out exercises.

After a few days' rest in the roads of Salin d' Hyères, which was used in discussing the strategic maneuvers, the practice fleet arrived off Toulon at about 11 a. m. on July 11 for the purpose of replenishing her stores, especially coal and feed water. As is well known, the necessary steps for equipping the wharves with lighters, etc., had been taken in good season on the part of the dockyard, but the lighters in possession of private individuals seem not to have been called into requisition.

The commander in chief had, in a general order, held up the work of the English fleet as an example worthy of imitation, and as shown by the work of the crews their ambition was not excited in vain.

For coaling, the fleet was divided into two parts. Immediately after making fast the lighters were towed by harbor tugs alongside the first group (the Mediterranean Squadron and the coast-defense vessels), which were ready by 7 p. m. Night work was forbidden. The second group (the North Squadron) had to wait a long time in vain for the lighters, as difficulties arose about the workmen. The Italian laborers, whom a contractor had engaged to fill the lighters, struck, and had to be replaced by 200 sailors of the station and the ships of the reserve. Moreover, the dockyard lacked railways, trucks, and lighters. In consequence of this, the cruisers *Cassard*, *Du Chayla*, *Dupuy de Lôme*, and *Latouche-Tréville* had to proceed to the landing pier, where, according to the programme, only the small cruisers were to coal. By evening 1,500 tons of coal were still to be taken aboard. The 14th of July was a national holiday, and the coaling was finished on the 15th. The additional fitting out with water, lubricating materials, and fresh provisions for eleven days was completed on the evening of the 16th. No ammunition was taken aboard.

There were to be transferred altogether 14,000 tons of coal, of which 7,800 tons were taken by battleships and 3,700 by cruisers in the roads; in the harbor, 2,250 tons by ships and 250 tons by torpedo boats; petroleum, 250 tons; lubricating oil, 208 tons; feed water, 1,500 tons; of provisions, 1,500 tons; drinking water, 7,000 kilograms; bread, 5,000 kilograms; meat, 11 live oxen and 20 mutton for each battleship; 8 and 16 each for cruisers of the first class; 7 and 12 for cruisers of the second class; 4 and 8 for cruisers of the third class. The provisions were brought on board by the ships' boats.

Admiral Gervais in a general order expressed his great satisfaction with the work done and the zeal of the officers and men, which had exceeded all previous records. The reports of the commanders contained suggestions of improvements in the coaling apparatus on board, which are to be taken into consideration in the future. The best results were also given, as follows:

Battleship *Gaulois*, 185 tons; *St. Louis*, 172 tons; *Carnot*, 166 tons;

Field of the French, Naval Maneuvers.

1901.

-  Fortified Ports
 Impregnable Ports.

Note:

 = Coast in possession of France, A & A'.

 = " " " " " Enemy, B & C.

 = Neutral Territory.



Plate I.

Massena, 154 tons; armored coast-defense vessel *Bouvins*, 135 tons; cruiser *Pothuau*, 90 tons; *Bruix*, 75 tons; *Cassini* and *Galilee*, 71 tons, average per hour each. The *Carnot* had the best record to show, 244 tons during one hour. This decision of the commander in chief may be accepted as just, although the record was still not equal to that of the English. In explanation of this there was cited the almost entire lack of the Temperley apparatus, and the fact that a great part of the coal was delivered in the form of briquettes. Whether the bunker holes are essentially smaller or more unfavorably situated than in ships of other navies, which was also cited in explanation, could not be determined.

The transportation facilities of Toulon only suffice for fully coaling in one day in the roads 9 armored coast-defense vessels and 4 cruisers. The strike of the workmen prevented the prompt refilling of the emptied lighters. One should, however, refrain from drawing from this exaggerated decision relative to the insufficient preparedness for war of the French navy, as has been done by some German papers. A strike of the coal carriers could be prevented in war, and in case of necessity night work could be employed. Moreover, in case of war the necessary lighters in private possession would be made available, which was probably not done for these exercises because of the cost. These fitting-out exercises are, therefore, not to be regarded as under war conditions, as they were only intended from the first to test the dockyard's own facilities, which, from the experiments made, suffice the fleet for times of peace, except in the matter of mechanical appliances for loading the lighters and delivering the coal.

Although three mines detonated in the entrance during a heavy thunder storm, no damage resulted.

TACTICAL EXERCISES.

On July 17 the practice fleet left Toulon and proceeded with exercises in evolution until the 20th, when it anchored in the roads of Salin d'Hyères. The cruiser division carried out scouting exercises and searched the coast, in accordance with the directions long since issued for the scouting service. The torpedo boats exercised under the leadership of the torpedo-boat destroyer *Foudre*, and made attacks by day against the fleet. *Foudre* also practiced with the captive balloon. This, with the detachment of aeronauts, was taken on board at Toulon on the 21st. While in the anchorage the fleet took on a supply of drinking water, which was brought to it in lighters from Toulon. The torpedo boats and the *Foudre* sailed from Toulon for Ajaccio on the 22d of July, and the squadron resumed the exercises of the previous week, to which were added sham battles and night attacks by the torpedo boats. Such an attack was made on the night of the 24th against the fleet anchoring in the roads of St. Tropez. The battleships were

lying next to land, farther out the cruisers in three lines, the outer one of which, with its searchlights shining in a fixed direction, formed a barrier of light inside of which the torpedo boats ran to and fro. The torpedo-boat attacks were unavailing. Practice with wireless telegraphy was zealously carried on. In the battle exercises there were worked out the tactical schemes which had been considered by the board on tactics, of which Admiral Gervais is president. It was chiefly an effort to prove the relative merits of the simple line ahead and the double echolons,^a in which the second line covers the gaps of the first. The commander in chief led the fleet of battleships with his flagship at the head of the second squadron, the cruisers representing the enemy. The two fleets moved off from each other in line abreast, the battleships of the squadron in double line abreast, the second squadron opposite the spaces of the first. The cruisers turned to the left and the battleships to the right and continued in parallel course. (See Plate III.^b) In the running fight which then took place so much steam and smoke was produced that for three-quarters of an hour no aim could be taken at the enemy and it was impossible to carry on the movements by signals. When it finally became clear, the cruisers were seen to turn to the left, whereupon Admiral Gervais surrounded the hostile line with his two squadrons, brought the end ships under double fire, and sent out his torpedo boats on attacks. All reports praise the skillful maneuver of the commander in chief, who unexpectedly attacked the hostile line from two sides.

On July 23 firing exercises were held under war condition and with "ship cleared for action," the commanders directing their ships from the conning tower and making special tests of the arrangements for the transmission of orders. The northern squadron fired against landmarks, the battleships against a low-lying battery on the Ile de Levant (Hyères), and the coast-defense vessels against an old battery occupying an elevated position on the same island. The battleships of the Mediterranean Squadron fired at moving targets, which represented the outline of battleships and armored cruisers, but on a very small scale. The armored cruisers of both squadrons, united under Rear-Admiral Gourdon, fired at a similar target, employing the Fournier tactics in so doing (steaming in a circle).

One group of cruisers tried firing indirectly at land targets which were concealed by intervening islands; another represented the defenses against torpedo boats, which were in turn represented by

^a A double echelon formation proposed by Captain von Lahrés, of the Austrian navy. "Die Flottenführung im Krieg auf Grund des Doppelstaffelsystems." Mittler, 1900.

^b The battle sketch is taken from the report of the "Moniteur de la flotte." That the second squadron should have first made a turn of 16 points and then of about 8 points more, as shown in the sketch of the "Moniteur," is very improbable.

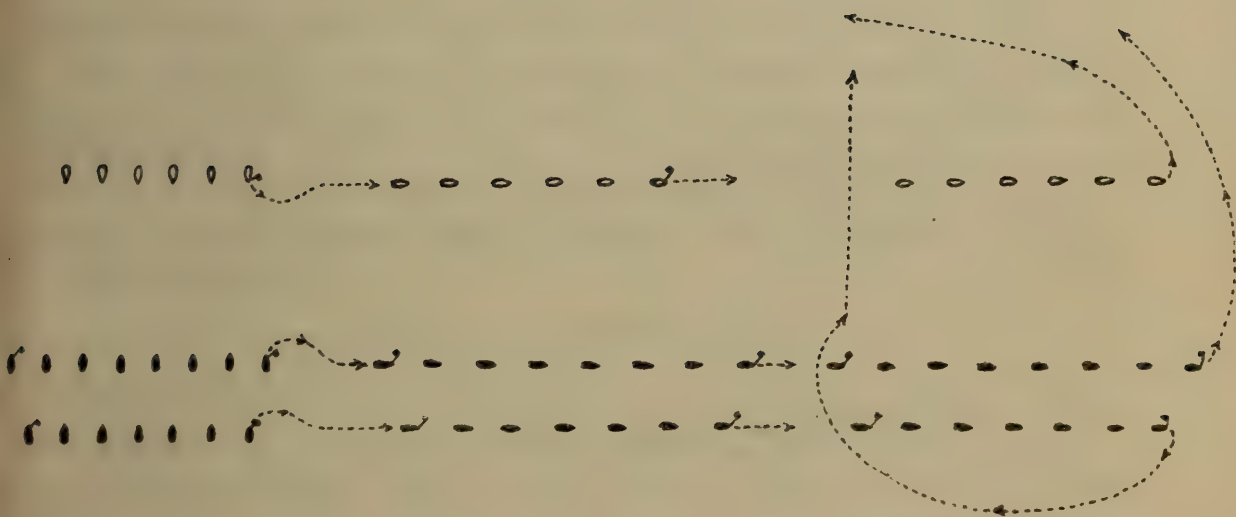


Plate III.

Tactical Exercises.

moving targets, while a third fired at a signal station on land. The targets for the torpedo-boat destroyers were rocks, which likewise represented torpedo boats, while the torpedo boats fired at towed targets.

The results of the firing are said to have been very good, especially considering the smallness of the targets and the comparatively rough seaway.

The speed of the fleet during evolutions was fixed at 8 knots for battleships, 13 for cruisers, and 15 for torpedo boats. According to one report, the speed of the battleship squadron increased to 12 knots during the fighting exercises in order to surround the cruisers.

The under way and anchor formations of the fleet seem to have been line abreast with the squadrons in line ahead, whereby the third and fourth squadrons were composed of cruisers with *Bouvet* as flagship.

The close of the exercises consisted in a display of the practice fleet in parade, evolutions, a sham battle of the two squadrons (North and Mediterranean) against the cruisers representing the enemy, maneuvers in double line ahead as compared with single, and a torpedo attack by night against a fleet in motion. The last failed on account of the moonlight.

LESSONS OF THE MANEUVERS.

It would require great circumspection to attempt to deduce from the French maneuvers precepts of a general nature for naval warfare, and form conclusions relative to the military efficiency of the French navy. The foregoing recital of the course of the exercises is based entirely upon the reports published in French professional and daily papers, and is therefore not to be regarded as unquestionably correct. Only the statements relative to the leading thoughts of the first part of the strategical maneuvers are probably approximately correct. The fundamental theme of the exercises was published some time before the beginning of the maneuvers, and fully discussed in the papers. It would be superfluous here to go further into the much-discussed question as to whether B and C represented the German and Italian or the English Channel and Mediterranean squadrons. That Squadron A was to represent the French Mediterranean and Division A¹ the North Squadron will be questioned by no one, or that the fundamental thought of the exercises set forth a possible and even a probable war situation, and that the task imposed upon Squadron A, namely, to prevent the meeting of Squadrons B and C, must under such a situation fall to the French Mediterranean Squadron.

The transmission of messages was quite in accordance with the conditions of war. A did not receive news of the entrance of B into the Mediterranean from Palma, Majorca, until noon of the same day; C first learned of the place of rendezvous with B on the morning of the

following day, and B and C were not informed of the whereabouts of A and A¹. On the other hand, A learned of the place of meeting of B and C through an intercepted message by wireless telegraphy.

In war just such uncertainties, delayed information, and intercepted messages must be reckoned with.

Considering the expanse of sea room, the number of scouting ships was too small on both sides. That Squadron B was able to turn back unobserved on the evening of July 5 can also be attributed to the lack of cruisers, unless scarcity of coal had something to do with it. On the part of B the cruisers paid no attention to the first principal of scouting service, namely, to serve as the eye and the protection of the nucleus of the fleet. The conduct of the *Du Chayla* in leading the hostile scouts under the guns of her own main body forms a laudable exception.

The importance and at the same time the difficulty of reliable scouting was again shown.

The strategic value of speed was not properly emphasized in the maneuvers. This was due to the fact that the originally faster French side was prevented by a lame ship from utilizing her superior speed. The *Brennus* was taken from the reserve and placed in commission shortly before the maneuvers, and manned with a personnel that was deficient both in number and in training, so that she became a drag upon her squadron. This can also happen in war, and, together with results of the battle of Ajaccio, further discussed below, teaches a noteworthy lesson, indeed the most important of the whole maneuvers, namely: Full preparedness for battle of a battle fleet can only be attained by constantly keeping battleships in commission, and the entering of ships with insufficiently trained personnel will be a disadvantage to the fleet.

The measures taken by Squadron A in the blockade of Ajaccio did not suffice to insure the main body against surprise, even if the torpedo attacks by B were successfully repelled. An inner line taking in the whole width of the bay, with ships cruising in between the outer main body, would probably have been more suitable after the coast had been cleared of torpedo boats.

Of the tactical maneuvers the naval battle of Ajaccio claims the greatest share of interest, as here both squadrons had full freedom of movement. Both were line ahead and the battle fell to the better managed, maneuvering as a whole, although it was the weaker and slower. The battle of the two squadrons and their cruisers in line ahead on opposite courses was broken off when the faster changed to fighting in a circle. To what extent the squadrons had freedom of movement in this and in the later exercises under the commander in chief, described above, is not clear.

It is also, for that reason, difficult to decide whether the double

formation was shown to be superior to the single. In one of these exercises the smoke and steam clinging to the double line made all movement impossible for three-fourths of an hour, and prevented any opportunity for the artillery, as the ships opposite the spaces could not fire. The outcome of the battle of Ajaccio shows how even a single line ahead of six ships can, through a misunderstood or incorrectly executed signal, become a helpless mass, and this incident should lead to caution in the use of the double formation in battle.

From the battle and battle exercises it is distinctly seen that constant training in union and a simple, accurately operating system of signaling are the fundamental conditions for the use of squadrons in battle, and that a well-trained squadron which is under the control of its leader will have the advantage from the outset under circumstances otherwise equal.

Some comment on the rules of the maneuvers should be made here. Each ship had received a number, which represented its military value, and there were rules for the decision of battles and the reduction of the military value. The opinion is held that this arrangement is too mechanical, which was in fact shown by the judge deciding contrary to the rules relative to the battle of Ajaccio. The number representing the military value did not show what share was given to offensive and defensive power and to speed in determining it, which was of the very highest importance in tactical maneuvers. Serious questions arise relative to the numbers assigned to separate armored ships, which can not be more fully discussed here. The conditions for successful torpedo fire appear too difficult. The fact that the torpedo attacks were all unsuccessful may perhaps be due to this. It should moreover be stated that attacks were also attempted in broad day, without any covering, which is no way suited to the character of the weapon. That torpedo boats and destroyers are not suitable for scouting ships is no new discovery.

The two submarine attacks took place by day and against ships at rest; the torpedo struck and the boat was not discovered in advance, in spite of the fact that in one case it was known that the attack was imminent. That would seem to show that under especially favorable conditions the submarine has chances of success. That its field of vision in the submerged state is very limited is shown by the fact that the *Gustave Zédé*, after its successful shot against the *Jauréguiberry*, emerged exactly in front of her bow, so that it was only by a skillful maneuver on the part of the battleships that she escaped being run down.

The wireless telegraph was diligently used, but with no satisfactory results, the chief difficulty being that the apparatus was sensitive to all messages. Thus, the *Bouvines* took up the message of an English cruiser on the way from Cadiz. Communications were understood up to a distance of 70 kilometers.

The captive balloon was not used in the actual maneuvers. An investigation of the works by the armored cruisers, which in this connection also placed distance buoys for the battleships, preceded the attack upon Algiers. The bombardment of Ajaccio took place after previously clearing the coast of torpedo boats, a certain portion being assigned to each of several groups of ships. Both bombardments were executed in motion and were successful; the works, however, are said not to have been at full efficiency.

Of the steam colliers only the *Japon*, equipped with the Temperley apparatus, was used during the maneuvers for coaling the ships off the Algerian coast; the two belonging to the North Squadron were emptied at Tangier. According to other reports, they were used in coaling exercises at sea in the passage of the North Squadron on its way to the scene of the maneuvers. In regard to the conclusions to be drawn relative to the preparedness of the French navy for war, there should especially be pointed out the good condition of the material, which was equal to the demands made, particularly the engines and boilers, and the good training of the personnel of the ships constantly in commission. Whether the inferior execution of the *Brennus* was due to the untrained personnel and not to her having been in the reserve can not be determined. Only one case of accidents to the engines occurred, although various leakages are said to have appeared in the boilers. In spite of the oppressive heat at times, and the forced steaming, the engine personnel, with the exception of the two ships newly placed in commission, showed itself fully equal to its task, and was especially commended by the commander in chief in his farewell general order. In this connection it should be noted that the speed of the battleships did not in general exceed 13 knots, and that this maximum speed was used only during the strategic maneuvers, and that even here it was not uninterrupted.

The evolutions of the fleet show a decided improvement over those of the previous year. There was but one collision, which occurred between two torpedo boats during a night attack. The average speed of the fleet was only a moderate one—8 knots for battleships, 13 knots for cruisers, and 15 knots for torpedo vessels. The distance between ships was 400 meters and between squadrons 600 meters.

Of the squadrons, A was the only approximately homogeneous one, although the *Brennus* was not of the same type as the three other battleships.

The scouting service was not managed according to a uniform system and failed utterly in part. Cruisers were needed everywhere.

The moderately high sea way on the run from Mers-el-Kebir to Ajaccio was sufficient to influence the speed of the squadron, which fell to 12 knots. *Bouvet*, *St. Louis*, *Charlemagne*, and *Gaulois* maintained this easily, and could use all their guns; *Charles Martel* and

Jauréguiberry were not quite up to the mark, and the armored coast-defense vessels *Bouvines* and *Amiral Tréhouart* would have had difficulty in using their guns. The cruisers behaved well. The torpedo dispatch boats *Lahire* and *Hallebarde* and the torpedo-boat destroyers could not maintain 12 knots, and the torpedo boats had to struggle hard. The decision of the French professional papers seems to be that only armored and large cruisers should belong to battleship squadrons, and that the smaller vessels are only a burden and impede the movements. According to all reports, the torpedo boats and mobile defenses failed to fulfill the expectations placed in them. They were manned by too old officers, in whom caution outweighed energy, and who, moreover, were too much subdued by the very severe consequences in case of injuries. The tactics were shown to be deficient and in need of improvement.

The success of the *Gustave Zédé* was acknowledged, but it was also cited as an objection that her limited radius of action rendered impossible any independent performance without the escort of a steamship, which in war would always betray her.

The firing of the fleet was good, the targets corresponding to the class of ship chosen; the exercise well planned, executed under war conditions. The guns and their appliances worked faultlessly with the exception of the 37 mm. machine guns, where many cases of difficulty in loading (*Ladehemmung*) occurred. The firing was done with service ammunition. *Brennus* sustained an injury to the forward turret.

The wireless telegraphy left much to be desired. The North Squadron succeeded better than the Mediterranean, and the *Masséna* and *Dupuy de Lôme* did the best. Fourteen ships were equipped with apparatus.

The coast guard and communication services were satisfactory.

The mobilization at Toulon showed that all preparations had been appropriately made.

The attack upon Ajaccio showed the necessity for stronger defenses for this wide bay if it is to serve as the point of support for a fleet. A fort should be established on the Sanguinaires and a battery on Sette Nave.

The same holds true for Algiers and Mers-el-Kebir. The strategic importance of this point was especially brought out by the strategic maneuvers. The mobile defenses were not sufficient; a cruiser division must there find her point of support for the surveillance of the straits.

The experiments in coaling will lead to more suitable arrangements for coaling on board warships and at dockyards.

CONCLUSION.

If one collects everything into a final statement, the decision would be that the maneuvers were planned with a view to the conditions of

war, were scientifically carried out, and reflect all honor upon the commander-in-chief. They furnished an excellent school for the commanders of the squadrons and ships, and for the officers, inspiring them, as this time they had access to the plans, and offered the crews an opportunity to show their training and endurance. The tactical exercises brought new truths to light and showed that the training of the two squadrons in evolutions was equal. No accidents worthy of mention occurred, and the material met the demands made upon it.

All reports praise the inspiring zeal of the commander in chief. His efficiency and that of the practice fleet received high recognition from the minister of marine and the President of the Republic in the bestowal of the grand cross of the Legion of Honor.

In publishing the ideas underlying the strategic maneuvers a French paper states as follows: "Our navy is entering upon a new era, of which the watchword is 'Attack!' The time is past when the only thought will be to creep into the harbors at the outbreak of war and allow ourselves to be blockaded there."

From this point of view the French maneuvers of this year are especially noteworthy.

SECTION III.

OPERATIONS OF FRENCH SUBMARINES.

Considerable interest attaches itself to the various exercises in attacks which have been practiced during the year by French submarine boats.

The French are the principal exponents of this type of naval element and have devoted great attention to it, having by far the greatest number of submarine boats, and in consequence greater experience. France relies upon this type of craft as a strong element of coast or harbor defense, and while the result of the attack of the *Gustave Zédé* may appear to furnish sufficient ground to justify the faith held in the submarine, nothing but practical experience in war can definitely decide its absolute value.

England, Germany, and Russia are developing the submarine, but very little information is obtainable concerning the progress in the two last-named countries.

At Cherbourg the submarines *Morse* and *Algerien* and the submersible *Sirene* attacked the turret ship *Bouvines* while the latter was riding to a buoy in the harbor. The boats left the harbor under water and the *Bouvines* was to repel their attacks by gun fire as they rose to the surface to fire their torpedoes. The *Algerien* was put out of action. The other two boats fired their torpedoes, fitted with exercise heads, before they were observed on board the *Bouvines*.

Similar experiments were made by the *Narval*, *Morse*, and *François* against the torpedo gunboat *Cassini*, as the latter, forewarned, was entering the port. The *Cassini* was hit by torpedoes from all three of the boats. The *François*, however, remained so long above water before discharging her torpedo it was adjudged that in actual combat she would have been destroyed.

The *Amiral Trehouart* was likewise successfully attacked as she was entering the harbor.

On January 7, 1902, there was a general attacking drill with the *Morse*, *François*, *Narval*, *Espadon*, and *Triton* against the *Bouvines*, *Amiral Trehouart*, and *Cassini*.

The first two guarded the west entrance to Cherbourg, the other three the east entrance, with the *François* north of the breakwater.

The *Bouvines* and *Cassini* entered from the westward. The *Bouvines* was hit by the *Morse* at 100 meters, but the *Cassini* escaped the *Narval* on account of her speed. She was, however, hit by the *François*.

The *Amiral Trehouart* destroyed the *Triton* by gun fire, but was later hit by the *Espadon*. The *Triton* had been obliged to rise to avoid a fishing boat, and thus exposed herself to the fire of the *Amiral Trehouart*.

The French papers lay great stress on the fact that these drills took place during the stormy winter season and therefore speaks much for the seaworthiness of the boats.

Their tactics seem to be attacks against ships lying still in the water, or to wait for ships moving in narrow passages.

Perhaps the most interesting attack was that of the *Gustave Zédé* off Ajaccio during the naval maneuvers of 1901.

The *Zédé* left Toulon for Ajaccio in tow of a Government tug. Upon nearing Ajaccio the tug was dismissed, the *Zédé* lying on the surface of the water to wait for the enemy. Upon two cruisers leaving their anchorage the *Zédé* sank, but later rose to the surface, and seeing the battleships still at anchor, and having in the meantime approached the battleships, took bearings for an attack. When the battleships began to move the *Zédé* again sank, and as the *Charles Martel* passed over the submarine a torpedo was fired into the *Martel*. In rising, after having successfully attacked the *Martel*, the *Zédé* was nearly run down by the *Jauréguiberry*.

Accounts vary as to Ajaccio being considered an impregnable port, and consequently of ships at anchor there being relieved of the necessity of a lookout for such attacks.

It is intimated that the commander in chief of the maneuvers indirectly warned the squadron of the possibility of an attack by the *Zédé*. The presence of the *Zédé* seems to have been unsuspected until she discharged her torpedo.

The submarine left under her own power for Toulon, arriving there in safety at an average speed of 8 knots.

This attack seems to have been made from below the surface. All the reports of previous attacks speak of the boats rising to the surface to discharge their torpedoes. This would indicate the slight value of the periscope.

GERMANY.

GERMAN NAVAL MANEUVERS, 1901.

The German naval maneuvers for 1901 consisted principally of tactical and scouting exercises, including no large strategic scheme.

Little authentic information has been published concerning the maneuvers.

The tactical exercises were carried out under full speed, and as a course of instruction, were very valuable to those engaged in them.

RUSSIA.

RUSSIAN NAVAL MANEUVERS.

The Russian maneuvers, from a naval point of view, contained little of importance.

The strategical assumption in the case under consideration was to the effect that the national squadron had suffered defeat and that over-sea operations by the enemy had become possible.

SECTION IV.

BRITISH MANEUVERS OF 1900.

The Admiralty account of the naval maneuvers of 1900, having been published for the first time, is given herewith as being supplementary to the account of the maneuvers appearing in the annual of last year.

[Admiralty narrative.]

PRELIMINARY ORDERS AND INSTRUCTIONS.

GENERAL ORDERS AND INSTRUCTIONS.

A partial mobilization of the fleet for maneuvers will take place this year. The vessels mobilized will be attached to the Channel and Reserve squadrons. They will assemble as soon as ready, under the orders of the flag officers in command, at Portland and Torbay, respectively, and will be formed into two fleets, to be known as Fleet **A** and Fleet **B**, respectively.

At the time appointed the main fleets will proceed to sea for the usual preliminary cruise, during which the ships will be exercised and anchored at the discretion of the admiral in command.

Two flotillas, composed of cruisers, torpedo gunboats, and destroyers, will be attached to **B** Fleet.

The vessels belonging to these two flotillas will assemble at Torbay, and will be organized thus:

Severn, 2 torpedo gunboats, Devonport division of destroyers.

Brilliant, 5 torpedo gunboats, Portsmouth and Chatham divisions of destroyers.

They will then proceed as follows:

Severn and flotilla to Lamlash;

Brilliant and flotilla to Milford Haven;

where they will be exercised and will coal, care being taken that all are complete with coal before the commencement of hostilities.

Two flotillas, composed of cruisers, torpedo gunboats, and torpedo boats, will be attached to **A** Fleet.

The vessels belonging to these two flotillas will assemble at Devonport, and will be organized thus:

Pactolus, Perseus, Pioneer, Hecla, 5 torpedo gunboats, Portsmouth and Chatham divisions of torpedo boats.

Mersey, Prometheus, 2 torpedo gunboats, Devonport division of torpedo boats.

They will then proceed as follows:

Pactolus and flotilla to Berehaven;

Mersey and flotilla to Lough Swilly;

where they will be exercised and will coal, care being taken that all are complete with coal before the commencement of hostilities.

Any portion of the Berehaven flotilla can be sent thence to Queens-town, provided that it arrives there and is completed with coal before the commencement of hostilities.

At the termination of the preliminary cruise the ships forming Fleet **A** will be formed into three divisions, and those forming Fleet **B** into two divisions. They will then be detached to the following base ports:

A1 to Berehaven.

A2 to Lough Swilly.

A3 to a rendezvous.

B1 to Pembroke.

B2 to Lamlash.

The order to commence hostilities will be sent on the day on which the ships arrive at their base ports.

The period of active operations will last ten days. On the conclusion of the maneuvers, the ships and vessels will proceed to carry out target practice, separately in the case of the mobilized ships, ample time being allowed for the careful performance of the practice; in the case of others, separately or in company, at the discretion of the admiral in command.

Only one-half of a quarter's allowance of ammunition is to be expended from the heavy, light, quick-firing, and machine guns of the mobilized ships.

A full quarter's allowance of ammunition may be fired from destroyers and torpedo boats if considered desirable by the officer commanding the flotillas.

Only such naval stores as are necessary to keep destroyers and torpedo boats efficient during the maneuvers are to be embarked in the depot vessels **Hecla, Mersey, Severn, Brilliant** during the mobilization. No ordnance or torpedo depot stores will be required.

A copy of the ship's and signal log of every vessel taking part in the maneuvers, commencing twelve hours before and ending twelve hours after the active operations, is to be sent to the Admiralty with the report of the admiral in chief command of each fleet.

List of vessels taking part in the maneuvers.

FLEET A.

A1.

Majestic.
Repulse.
Dreadnought.
Sultan.

A2.

Jupiter.
Resolution.
Edinburgh.
Conqueror.

A3.

Magnificent.
Prince George.
Hannibal.
Mars.

CRUISERS.

Diadem.
Blake.
Edgar.
Gibraltar.
Immortalité.

Gladiator.
Talbot.
Furious.
Naiad.
Sirius.
Apollo.
Retribution.
Phœbe.

FLOTILLAS.

Pactolus,	42, 49,
Perseus,	50, 59,
Pioneer,	66, 71,
Spanker,	76, 77,
Sheldrake,	81, 82,
Seagull,	83, 84,
Skipjack,	63, 64,
Jason,	68, 74,
Hecla.	
Mersey,	51, 52,
Prometheus,	53, 55,
Speedwell,	57, 58,
Sharpshooter.	85, 86.

FLEET B.

B1.

Alexandra.
Colossus.
Rodney.
Howe.
Collingwood.
Camperdown.
Hero.
Thunderer.
Superb.

B2.

Sanspareil.
Nile.
Trafalgar.
Benbow.

CRUISERS.

Ariadne.
Blenheim.
Hawke.
St. George.
Galatea.

Vindictive.
Minerva.
Cambrian.
Rainbow.
Melampus.
Andromache.
Medea.
Medusa.

FLOTILLAS.

Brilliant,	{ Faun, Flirt, Flying Fish, Kestrel, Spiteful, Star, Sylvia, Violet (Portsmouth division); An- gler, Ariel, Aron, Bittern, Cheer- ful, Cynthia, Mallard, and Mermaid (Chatham divi- sion).
Alarm,	
Renard,	
Leda,	
Circe,	
Jaseur.	
Severn,	{ Leopard, Leren, Locust, Panther, Seal, Shark, Thrasher, Wolf (Devonport division).
Antelope,	
Gleaner.	

INSTRUCTIONS TO THE VICE-ADMIRAL OF FLEET A.

At the termination of the preliminary cruise the ships forming Fleet A are to be formed into three divisions and are to be detached in time to arrive, using ordinary speed, on Monday, July 23, between 6 a. m. and noon, as follows:

A1 at Berehaven.

A2 at Lough Swilly.

No vessel, except those belonging to the flotillas, is to arrive before 6 a. m.

The cruisers are to be allotted to the three divisions as the vice-admiral considers advisable, but no division should have less than two.

The officer in command of each division is to report by telegraph to the Admiralty, without any delay, his arrival at the port named, and is at the same time to name any ship which has not arrived, the reasons for its absence, and its movements.

A3 is to be detached in time to cross the forty-fifth parallel, steaming at 8 knots, by midnight on July 23, and with orders to proceed to a rendezvous in latitude 44° north, longitude 14° west, and on arrival at the rendezvous the senior officer is to open his sealed orders. Before **A3** is detached the movements of that squadron after leaving the rendezvous are to be arranged by the vice-admiral.

On receipt of the telegram ordering the commencement of hostilities, which may be expected on July 23, endeavor is to be made to obtain the command of the sea from the enemy.

The hour when the reinforcement from the Mediterranean may be assumed to pass Gibraltar will be communicated by telegraph.

A copy of the instructions issued to the rear-admiral in command of *B* fleet is attached.

INSTRUCTIONS TO THE REAR-ADMIRAL IN COMMAND OF *B* FLEET.

At the termination of the preliminary cruise the ships forming *B* fleet are to be formed into two divisions and are to be detached in time to arrive at ordinary speed on Monday, July 23, between 6 a. m. and noon, as follows:

B1 at Pembroke.

B2 at Lamlash.

No vessel, except those belonging to the flotillas, is to arrive before 6 a. m.

The cruisers are to be allotted to the divisions as the rear-admiral considers advisable, but no division should have less than two.

The officer in command of each division is to report by telegraph to the Admiralty, without any delay, his arrival at the port named, and is at the same time to name any ship which has not arrived, the reasons for its absence, and its movements.

On receipt of the telegram ordering the commencement of hostili-

ties, which may be expected on July 23, endeavor is to be made to obtain the command of the sea from the enemy.

The hour when the reinforcements for **A** may be assumed to pass Gibraltar will be communicated by telegraph.

A copy of the instructions issued to the vice-admiral of **A** fleet is attached.

SEALED ORDERS FOR THE SENIOR OFFICER OF **A3**.

You will remain on or about the rendezvous in

Latitude 44° north,

Longitude 14° west,

until 1 a. m. on July 28, when you will proceed as arranged by the vice-admiral.

INSTRUCTIONS RELATIVE TO UMPIRING.

The following officers have been nominated to act as umpires: Vice-Admiral Sir Compton Domville, K. C. B., Rear-Admiral C. C. Penrose Fitzgerald, Rear-Admiral A. D. Fanshawe.

Lieut. Gen. J. F. Owen, R. A., has been nominated by the war office to act as military umpire to decide, jointly with the naval umpires, claims arising between the land defenses and the ships.

They will meet at the Admiralty, Whitehall, where all claims and statements for their consideration should be sent, addressed to the "Secretary of the Umpires." Claims, etc., are to be sent in as soon as possible after the events to which they refer, on a form as shown below. They should be accompanied by extracts from the ship's log or signal log, by track charts when necessary, or by other documentary evidence likely to assist the umpires in arriving at a decision. Claims, etc., sent by telegraph must be followed by the same claim, etc., on the proper form, sent by the first post.

Claim from.^a

Name of vessel.	By whom claimed.	Nature of claim.	Date.	Greenwich mean time.	Place.	Remarks.

^a Here insert the "fleet" from which the claim is sent.

The decisions of the umpires are final.

Umpires will not make known their reasons for arriving at a decision.

No reference will be made by them to the Admiralty before arriving at a decision.

The decisions of the umpires will be communicated to the Admiralty as soon as possible after they have been arrived at, in order that if desirable they may be made known to the senior officer on each side.

Should the Admiralty desire to communicate with the fleets during the progress of "hostilities," and their instructions be conveyed by a ship attached to either of the opposing forces, or by any other ship, such a ship is to display the signal "A K H."

It will thus be known that she is acting under Admiralty orders, or is about to deliver dispatches or telegrams, or to signal orders received from the Admiralty, and the respective admirals and senior officers are to take the necessary steps to insure that the orders so communicated are forwarded and acted on without delay.

If the commanding officer of one vessel sights another flying the signal A K H he is at once to close her so as to place himself at a convenient distance for communicating by signal, should it be necessary.

OBJECT OF THE MANEUVERS.

The principal object of the maneuvers is to obtain information relative to the working of a fleet which is composed of vessels of all classes, and is fighting for the command of the sea.

The most suitable distance at which to establish a temporary base for a squadron watching a hostile fortified fort is a subsidiary question.

The power which cruisers may or may not possess of hunting down and driving torpedo craft into port is another important point.

GENERAL IDEA OF THE MANEUVERS.

A fleet (*B*) is divided into two squadrons:

*B*1 at Milford.

*B*2 at Lamlash.

A hostile fleet (*A*), inferior in battleships to (*B*), is also divided into two squadrons:

*A*1 at Berehaven.

*A*2 at Lough Swilly.

A hostile reinforcement (*A*3) which will make *A*1 + *A*2 + *A*3 nearly equal to *B*1 + *B*2 in battleships, is expected from the Mediterranean.

The whole of Ireland is hostile territory, and belongs to (*A*). The whole of Great Britain, from Cape Wrath to the Lands End, the Isle of Man, and the Scilly Islands belong to (*B*).

The fleet (*B*) has destroyers.

The hostile fleet (*A*) has torpedo boats, supported by fast small craft.

The following ports are fortified and will be placed in a state of defense:

In Great Britain: Milford Haven.

In Ireland: Berehaven.

Queenstown.

Lough Swilly.

All other ports, including Lamlash, are unfortified.

Each fleet will try to obtain command of the sea, that is to say, will

endeavor to defeat the other, to shut him up in his ports, and especially to clear the sea of his torpedo craft.

RULES AND REGULATIONS TO BE OBSERVED DURING THE MANEUVERS.

The maneuver field is bounded—on the west by the twentieth meridian; on the north by the sixtieth parallel; on the east by the fifth meridian as far as Cape Wrath, by the west coast of Great Britain, and by the meridian of the Lizard Head from that point to the southward; on the south by the forty-fifth parallel.

The signal stations marked on the special chart^a issued with the instructions for the distribution of intelligence will alone supply information during the maneuvers.

As soon as the whole of the ships and vessels composing the two fleets, together with the destroyers and torpedo boats, have arrived in port, a telegram will be sent from the admiralty naming the hour when hostilities are to commence.

No vessel of any class is to put to sea before the hour named for the commencement of hostilities.

Battleships are to complete with coal on arrival at their base ports before again putting to sea.

All battleships are to be considered equal in fighting power to **Majestic**.

No rules setting forth the conditions under which ships will be put out of action will be issued. Each case must be decided by the umpires on its merits on the basis of what would be probable in war.

When two or more ships come into action the commencement of the engagement is to be marked by the firing of a gun by one of the ship engaged. During the engagement single guns are to be fired at five-minute intervals by one ship on each side.

When either side considers that he has beaten the other, he should signal "Propose reference to umpires." If the other agrees to the reference the action is to cease. If the other does not agree the action may continue, but not for more than a reasonable time, which is to be determined by the senior officer present. A reasonable time under ordinary conditions would be one hour in the case of battleships, cruisers, and torpedo gunboats, and half an hour in that of destroyers and torpedo boats.

When reference to the umpires has been settled, the senior officer present is to determine what ships on either side are to proceed into port to await their decision, pending which the ships detached are to be considered out of action. The senior officer present must take care to select as far as possible equally from both sides.

If a ship is undoubtedly torpedoed, or manifestly overpowered by a much superior force, the senior officer present may take the responsi-

^a Not reproduced.

bility of temporarily putting such ship out of action and ordering her into port for the decision of the umpires. In this case it will not be obligatory to order into port a ship from the opposite side.

Ships put out of action can take no further part in the maneuvers, but must return to one of their base ports—Milford, Lamlash, Berehaven, or Lough Swilly—flying the Blue Peter at the fore. They are to select a route as far as possible clear of the scene of operations, and are strictly enjoined not to communicate any information to the ships on either side which they may meet on the way.

Colliers, after reaching Milford, Lamlash, Lough Swilly, Berehaven, or Queenstown, are open to capture; the captors can use the coal in them.

Colliers are not to be interfered with after they have discharged their cargoes.

Signal stations are not open to attack by landing parties.

As the 18-inch torpedo can not be fired at a ship in a peace exercise, a destroyer is to fire a blue light by night or blow her whistle by day at the moment when the torpedo would be discharged, the tube being trained and all adjustments made as if actually firing.

Torpedoes fitted with collapsible heads may be fired at battleships and cruisers, but not at torpedo gunboats, destroyers, or torpedo boats.

Torpedo boats are not to paint out their numbers.

As it is assumed that the command of the sea is disputed, care should be taken not to expose vessels needlessly to fire from forts.

NARRATIVE OF EVENTS.

The torpedo boats were commissioned at their respective ports on July 3, where they carried out some preliminary exercises, and left in time to arrive at Devonport on July 14, and from there the flotillas were dispatched to Berehaven and Lough Swilly, respectively. A part of the Berehaven division was detached to Queenstown on July 19, so that on the outbreak of hostilities the flotilla was equally divided between Lough Swilly, Berehaven, and Queenstown.

The destroyers assembled at Torbay on the 14th, and the divisions left for Lamlash and Milford, respectively, on July 16.

The fleets left their ports of assembly on Monday, July 16, for the preliminary cruise, and soon after the appointed time, namely, 6 a. m. on Monday, July 23, **A1**, **A2**, and **B2** had anchored at their base ports and immediately commenced to coal. **B1** did not anchor in Milford Haven until about 8 p. m., having been prevented from entering the harbor by a dense fog.

At 10 p. m., Monday, July 23, the Admiralty telegraphed that hostilities were to commence at 2 a. m. on July 24, and cease at 2 a. m. on August 3.

All the battleship divisions put to sea soon after 2 a. m. on the 24th,

except *B1*, which did not leave Milford until 11 a. m. on the 24th. The admiral at Milford did not receive the complete telegram announcing the commencement of hostilities until 6 a. m.; this, however, did not affect the departure of the battleships, as they had not completed coaling until 8 p. m.

At 7 a. m. on Wednesday, July 25, the Admiralty telegraphed to inform the admirals in command of *A* and *B* Fleets that *A3* passed Gibraltar at 5 a. m. on the 25th, at a speed of 10 knots.

A1 and *A2*, with the exception of the *Edinburgh* and *Conqueror*, which were left at Lough Swilly, met off Blacksod Bay on the evening of Tuesday, the 24th.

B1 and *B2* had also arranged to meet off the west coast of Ireland, passing through a series of rendezvous well clear of the Irish coast. They met at 2 o'clock on Wednesday afternoon, the 25th, in latitude $52^{\circ} 9'$ north, longitude $11^{\circ} 28'$ west. *B1* engaged some of *A*'s cruisers early on Wednesday morning. From the track chart ^a it will be seen that at midnight on the 24th *B2*, going south, passed *A1* and *A2*, going north, at a distance of about 3 miles. Neither fleet, however, knew of the other's proximity. There was a fog at the time.

A1 and *A2*, after combining, proceeded to Lough Swilly with the intention of attacking the enemy's ports, etc., in the north, but information having been received that *B1* had been seen off Malin Head and that *B2* had rounded Brow Head, it was decided to meet the reenforcement (*A3*) before undertaking offensive operations. It also seemed probable that *A3*, which had been directed to come north along the fifteenth meridian, would be in danger of *B* Fleet in its full strength. Orders were therefore sent to *A3* to come north on the twentieth meridian (the extreme western boundary of the maneuver field), and *A1* and *A2* proceeded to this meridian and went south to meet the reenforcement. This junction was effected at 2 p. m. on Sunday, the 29th, in latitude $47^{\circ} 50'$ north and longitude $19^{\circ} 40'$ west. *A* Fleet then made for the south of Ireland and arrived off Queenstown at 9 a. m. on August 1, where they were joined by the southern flotilla of torpedo boats and several cruisers. *A* Fleet then steered for the St. Georges Channel, but the weather proved too bad for the flotilla, which was, therefore, ordered to Waterford. It was also found necessary to send the *Edinburgh* and *Conqueror* into Queenstown, as they could not keep up with the remainder in the heavy weather. The combined *B* Fleet was sighted at 10.20 a. m. on Thursday, the 2d, and *A*, being now reduced to 10 battleships, decided to turn to the southwest, and at the same time ordered the *Dreadnought* to proceed to Queenstown. The remainder of *A* Fleet (now reduced to 9 ships) proceeded at 13 knots until about 2 p. m., when, finding they were not dropping

^aSee chart at end of report.

B Fleet, the *Sultan* was ordered to proceed to Berehaven and the rest increased speed to 14 knots.

B Fleet having combined, steered to the westward for a distance of 140 miles, in order to be in a position to intercept *A3* on its way north, the admiral being under the impression that *A3* had started from her rendezvous on the outbreak of hostilities. The fleet, after steaming west for 140 miles, turned back again, and at 2.40 p. m. on the 26th, the news of *A3* having passed Gibraltar was received from a cruiser. *B* Fleet, at 8 p. m., steered to the northward, and after having ascertained that none of the enemy's battleships were in Lough Swilly, proceeded through the North Channel into the Irish Sea and remained there waiting for information of the enemy. Shortly before noon on August 1, when off Port Patrick, news was received that *A* Fleet had been sighted on Tuesday afternoon (31st) 60 miles south of Cork. *B* Fleet at once started south and sighted *A* Fleet in the St. Georges Channel about 10.20 a. m. on Thursday, August 2, and gave chase which was continued until 3 p. m. when, finding that there was no chance of bring *A* to action, *B* turned and steered for Milford, where the battleships arrived about 11 p. m., August 2.

Hostilities ceased at 2 a. m. on the 3d.

An action was fought between five *A* cruisers and four *B* cruisers, which resulted in one of *A*'s second-class cruisers being sunk, and a first-class cruiser on each side being put out of action.

It was intended to reserve the torpedo boats until the latter part of the period of hostilities, when it was hoped few of the destroyers would be in action; as it turned out, the weather during the last two days was too bad to make any use of them.

SUMMARY OF SHIPS AND TORPEDO CRAFT PUT OUT OF ACTION.

Belonging to A Fleet.

Gibraltar, cruiser first class.
Naiad, cruiser second class.
Speedwell, torpedo gunboat.
Seagull, torpedo gunboat.
Les Reaulx, distilling ship.

Belonging to B Fleet.

Hawke, cruiser first class.
Leda, torpedo gunboat.
Alarm, torpedo gunboat.
Renard, torpedo gunboat.
Spiteful, destroyer.
Kestrel, destroyer.
Thrasher, destroyer.
Locust, destroyer.
Wolf, destroyer.
Cheerful, destroyer.

UMPIRES' REPORT.

COMMITTEE ROOM, ADMIRALTY,
 August 18, 1900.

We have the honor to submit our report on the naval maneuvers of 1900.

I. The object of the maneuvers, given in the printed paper supplied to us, is:

(a) To obtain information relative to the working of a fleet which is composed of vessels of all classes, and is fighting for the command of the sea.

(b) The most suitable distance at which to establish a temporary base for a squadron watching a hostile port.

(c) The power which cruisers may or may not possess of hunting down and driving torpedo craft into port.

With regard to (a) not much information was obtained. We think that a really powerful fleet of battleships must be homogeneous in speed and coal supply, and that any vessel of inferior speed and deficient in the latter quality must seriously hamper the fleet. Neither **A** nor **B** Fleet obtained the command of the sea, though **B**, by reason of numerical superiority, was able on the last day of the maneuvers to put **A** to flight; still **A's** Fleet was uninjured, and his cruisers and torpedo flotilla intact. On the other hand, many of **B's** battleships would have had to coal during the next forty-eight hours, the flagship and two others having to coal at once, whereas the majority of **A's** ships were so much better off in this respect that they could have remained at sea for many days. We think that the commander of **A** Fleet took unnecessary trouble to avoid **B** Fleet in his efforts to form a junction with **A3**; his efforts in this direction caused loss of valuable time, when the maneuvers are so short, and a considerable expenditure of coal; moreover, we think that **A3** was well able to take care of itself, as its superiority in speed would have enabled it to escape, even if it had fallen in with the whole of **B** Fleet, and had it met with **B** Fleet, spread for the purpose of intercepting it, there is every probability that it might have inflicted considerable damage on a portion of **B** Fleet before the latter could concentrate and cause **A3** to retreat. It is not clear to us why **B2** Fleet was sent round the north and west of Ireland to join hands with **B1**, as it must run a risk of meeting a superior fleet, it being certain that **A1** and **A2** could only combine, without engaging a superior force, by meeting on the west coast of Ireland. As a matter of fact, **B2** passed within a few miles of **A1** and **A2** on the night of July 24, but were fortunately not seen.

The cruisers on both sides were well worked in groups of about equal speed, and gave some good results both in shadowing the opposing fleets, obtaining useful information, and suppressing the destroyers.

The torpedo boats were not employed, being kept in harbor by Vice-Admiral Sir H. Rawson for a final attack on **B** Fleet, which was not delivered, owing to bad weather on the last day of the maneuvers. The destroyers were very active, but appeared to think they had an immunity from gun fire, even in fine bright weather and at reasonable distances, which resulted in a good many captures, and would be quite inadmissible in actual warfare.

(b) It does not appear that any information was obtained as to the most suitable distance at which to establish a temporary base for a squadron watching a hostile fortified port.

(c) The maneuvers have shown that cruisers have a very considerable power in hunting down hostile torpedo craft, the third-class cruisers being particularly successful in this respect. This success was a great deal due to the destroyers' own initiative in getting too close to ships with long-range guns, when they had it in their power to get away; but we think that they should be supported by cruisers.

II. We would beg to submit that in future maneuvers the date for the conclusion of them should be unknown to the admirals, as the fixing of a date naturally causes the admirals in command to run their coal down to the very lowest limit consistent with safety, and causes them to adopt a course of strategy which might compel them to lose command of the sea at a critical time.

We further submit that a telegraphic claim should be sent by both sides as soon as possible after an engagement has taken place, giving following particulars:

1. Place.
2. Date and G. M. T.
3. Range.
4. Time under fire.
5. State of sea and weather.
6. Position and formation of opposing squadron or vessel.

This would assist the umpires in deciding each case quickly, prevent ships being detained in port for a length of time pending decision of the umpires, and thus the balance of power would not be upset by a number of ships being temporarily out of action. Written reports might be forwarded at the end of the maneuvers.

III. It appears that in several cases delay has been caused in the entry of friendly ships into their own fortified ports. This is the first time this scheme has been tried. The arrangement seems complicated and could be simplified with advantage.

IV. The information communicated by the signal stations to Rear-Admiral Sir G. Noel seems to have been very unsatisfactory and conflicting.

We have, etc.,

COMPTON DOMVILE, *Vice-Admiral*.

C. C. P. FITZGERALD, *Rear-Admiral*.

ARTHUR D. FANSHAWE, *Rear-Admiral*.

C. J. DORMER, *Commander, Secretary*.

Claims from **A Fleet.**

Vessel claimed.	By whom claimed.	Nature of claim.	Date.	G. M. T.	Position.	Decision.
1 destroyer, name unknown.	Dunree Fort, Lough Swilly	Disabled or sunk	July 24	9.03 a. m.	Off Lough Swilly	Disallowed.
H. M. S. <i>Sylvia</i>	H. M. S. Edgar	do	do	11.30 a. m. to 11.40 a. m.	Lat. 51° 25' N., long. 8° 40' W.	Do.
H. M. S. <i>Mermoid</i>	H. M. S. Talbot	Sunk	do	11.30 a. m.	Lat. 51° 34' N., long. 8° 14' W.	Do.
1 destroyer, name unknown.	H. M. S. <i>Immortalité</i>	Destroyed	do	11.32 a. m.	Lat. 50° 31' N., long. 9° 26' W.	Do.
H. M. S. <i>Mermoid</i> , <i>Angler</i> , and <i>Ariel</i> .	H. M. S. <i>Paetolus</i> , <i>Pioneer</i> , and <i>Seagull</i> .	Sunk or disabled	do	2.55 p. m. to 3.25 p. m.	South of Ballycotton; lat. 51° 45' N., long. 8° 0' W.	Do.
H. M. S. <i>Alarm</i> , <i>Leda</i> , <i>Brilliant</i> , and <i>Andromache</i> .	H. M. S. <i>Diadem</i> and <i>Talbot</i> .	Put out of action	do	4.07 p. m. to 5.30 p. m.	Lat. 51° 32' N., long. 7° 0' W.	H. M. S. <i>Leda</i> and <i>Alarm</i> allowed; <i>Brilliant</i> and <i>Andromache</i> disallowed.
H. M. S. <i>Bittern</i> , <i>Avon</i> , and 1 destroyer, name unknown.	H. M. S. Talbot	Sunk	do	8.35 p. m.	Entrance of Queenstown Harbor.	Disallowed.
H. M. S. <i>Mermoid</i>	H. M. S. Talbot	Captured	do	9.45 p. m.	Off Roches Point	Do.
H. M. S. <i>Spitfire</i>	H. M. S. <i>Hecla</i> and <i>Lonechort Fort</i> , Berehaven.	Sunk	July 25	12.05 a. m.	Eastern entrance of Berehaven.	Allowed.
2 destroyers, names unknown	H. M. S. <i>Diadem</i>	Put out of action	do	2.50 a. m.	Lat. 51° 23' N., long. 9° 51' W.	Disallowed.
4 destroyers, names unknown	H. M. S. <i>Immortalité</i>	Destroyed	do	2.45 a. m. to 3 a. m.	Lat. 50° 58' N., long. 9° 31' W.	Do.
H. M. S. <i>Kestrel</i>	H. M. S. <i>Gibraltar</i> , <i>Naiad</i> , and <i>Edgar</i> .	Sunk	do	3 a. m.	Lat. 51° 5' N., long. 9° 15' W.	Allowed.
H. M. S. <i>Renard</i>	H. M. S. <i>Diadem</i>	Put out of action	do	3.35 a. m.	Lat. 51° 1' N., long. 9° 26' W.	Do.
1 destroyer, name unknown.	H. M. S. <i>Immortalité</i>	Destroyed	do	4.15 a. m.	Lat. 51° 7' N., long. 9° 37' W.	Disallowed.
H. M. S. <i>Blenheim</i>	H. M. S. <i>Blake</i> , <i>Retribution</i> , and <i>Apollo</i> .	Put out of action	do	7.45 a. m. to 9.15 a. m.	Lat. 54° 53' N., long. 10° 28' W.	Do.
H. M. S. <i>Shark</i>	H. M. S. <i>Apollo</i> and <i>Perseus</i>	Captured or sunk	July 26	4.37 a. m. to 4.47 a. m.	Funad Point, S. 4° E., 8 miles.	Do.
H. M. S. <i>Thrasher</i>	H. M. S. <i>Prometheus</i>	Captured or destroyed	do	5.12 a. m. to 7.15 a. m.	Off Lough Swilly	Allowed.
H. M. S. <i>Panther</i>	H. M. S. <i>Blake</i>	Put out of action	do	9.48 a. m. to 10.20 a. m.	Lat. 55° 24' N., long. 7° 45' W.	Disallowed.

H. M. S. <i>Scal</i> , <i>Locust</i> , and <i>Wolf</i> .	H. M. S. <i>Speedwell</i>	Sunk	do.....	9.30 p. m.	Off Lough Swilly	Allowed for H. M. S. <i>Locust</i> ; disallowed for H. M. S. <i>Scal</i> and <i>Wolf</i> .
H. M. S. <i>Flirt</i>	H. M. S. <i>Diadem</i>	Put out of action	July 27	9.41 a. m.	Lat. 52° 2' N., long. 5° 58' W.	Disallowed.
H. M. S. <i>Wolf</i>	H. M. S. <i>Prometheus</i>	Captured or destroyed	do.....	11.50 a. m. to 12.05 p. m.	Off Lough Swilly	Do.
H. M. S. <i>Wolf</i> and <i>Leven</i>	H. M. S. <i>Prometheus</i> and <i>Skipjack</i>	do.....	do.....	2.48 p. m. to 3.11 p. m.	Malin Head, SE, 1 mile	Allowed for H. M. S. <i>Wolf</i> ; disallowed for H. M. S. <i>Leven</i> .
H. M. S. <i>St. George</i> , <i>Ariadne</i> , <i>Hauke</i> , <i>Vindictive</i> , and <i>Faun</i>	H. M. S. <i>Diadem</i> , <i>Edgar</i> , <i>Immortalité</i> , <i>Gibraltar</i> , and <i>Naiad</i>	Totally disabled	July 28	4.11 p. m.	Lat. 52° 43' N., long. 5° 30' W.	H. M. S. <i>Naiad</i> sunk; H. M. S. <i>Hauke</i> and <i>Gibraltar</i> to remain out of action.
H. M. S. <i>Renard</i>	H. M. S. <i>Prometheus</i> and <i>Perseus</i>	Sunk at anchor	July 31	11.40 a. m.	Campbeltown	Allowed, <i>Renard</i> not having heard that <i>Diadem's</i> claim for her on 25th had been allowed.
H. M. S. <i>Flirt</i>	do.....	Destroyed	do.....	12.31 p. m.	Sanda Sound	Disallowed.
H. M. S. <i>Rainbow</i>	H. M. S. <i>Prometheus</i> , <i>Perseus</i> , and <i>Skipjack</i>	Captured	do.....	5.30 p. m.	Dunaff Head	Do.
H. M. S. <i>Cheerful</i> , <i>Mermaid</i> , and <i>Bittern</i>	H. M. S. <i>Apollo</i> , <i>Retribution</i> , and <i>Phoebe</i>	do.....	Aug. 1	6.50 a. m.	Daunt Rock light vessel, NW. 7 miles.	Allowed for H. M. S. <i>Cheerful</i> ; disallowed for H. M. S. <i>Mermaid</i> and <i>Bittern</i> .
H. M. S. <i>Rainbow</i>	Forts, Lough Swilly	Sunk	do.....	12.45 p. m. to 1.14 p. m.	Off Lough Swilly	Disallowed.
3 destroyers, names unknown	H. M. S. <i>Jason</i> and <i>Spanker</i>	Put out of action	do.....	4.55 p. m. to 5.10 p. m.	Off Queenstown Harbor	Do.

Claims from B Fleet.

Les Beaulx (condenser ship).	H. M. S. <i>Leopard</i>	Claimed as prize	July 24	Not given	Off Lough Swilly	Allowed.
H. M. S. <i>Gibraltar</i>	H. M. S. <i>Kestrel</i>	Torpedoed	July 25	3 a. m.	Lat. 51° 5' N., long. 9° 15' W.	Disallowed.
H. M. S. <i>Diadem</i> and <i>Immortalité</i>	H. M. S. <i>Alexandra</i> , in company with "B1" battle squadron.	Disabled or sunk	do.....	3.24 a. m.	Lat. 57° 2' N., long. 9° 32' W.	Do.

Claims from *B Fleet*—Continued.

Vessel claimed.	By whom claimed.	Nature of claim.	Date.	G. M. T.	Position.	Decision.
H. M. S. <i>Speedwell</i>	H. M. S. <i>Seal</i> , <i>Locust</i> , and <i>Wolf</i>	Torpedoed and disabled by gun fire.	July 26	9.30 p. m.	Entrance of Lough Swilly ..	Allowed.
3 torpedo boats, numbers unknown.	H. M. S. <i>Minerva</i>	Put out of action	July 26 and 27.	10 p. m. to 4 a. m.	Off Bantry Bay, and Skelligs.	Disallowed.
H. M. S. <i>Prometheus</i>	H. M. S. <i>Wolf</i>	Torpedoed	July 27	3 p. m.	Malin Head, SE. 1 mile.	Do.
H. M. S. <i>Diadem</i> , <i>Edgar</i> , <i>Immortalité</i> , <i>Gibraltar</i> , and <i>Naiad</i> .	H. M. S. <i>St. George</i> , <i>Ariadne</i> , <i>Hawke</i> , and <i>Vindictive</i> .	To have sunk <i>Naiad</i> , ^a <i>Diadem</i> , ^a <i>Edgar</i> , ^a <i>Gibraltar</i> , ^a and <i>Immortalité</i> . ^b	July 28	3.35 p. m. to 4.10 p. m.	Lat. 52° 30' N., long. 5° 15' W.	H. M. S. <i>Naiad</i> sunk; H. M. S. <i>Hawke</i> and <i>Gibraltar</i> to remain out of action.
Searchlights, west side of entrance to Queenstown Harbor.	H. M. S. <i>Cheerful</i>	To have destroyed searchlights.	July 29	2 a. m.	Queenstown	Disallowed.
H. M. S. <i>Blake</i>	H. M. S. <i>Blenheim</i> and <i>Cambrian</i> ..	Put out of action	July 31	2 p. m.	Lat. 50° 40' N., long. 8° 45' W.	Do.
H. M. S. <i>Seagull</i>	H. M. S. <i>Andromache</i>	Captured	do.....	3 p. m.	Off Daunt Rock	Allowed.
H. M. S. <i>Skipjack</i>	H. M. S. <i>Rainbow</i>	Put out of action by gun fire.	do.....	4.30 p. m.	Off Malin Head	Disallowed.

^a Entirely crippled.^b Seriously damaged.

British Maneuvers, 1900

Showing Tracks of the Battleships of A and B Fleets.

Tracks of A 1, A 2 and A 3 Fleets shown thus
Track of A 1 and A 2 Fleets when joined
of A Fleets, combined
Tracks of B 1 and B 2 Fleets
Track of B Fleets, combined



VII.

NOTES ON NAVAL BUDGETS OF 1902-3.

By Lieutenant LOUIS M. NULTON, United States Navy,
Staff Intelligence Officer.

ENGLAND.

The following items are taken from the estimates for 1902-3:

EFFECTIVE SERVICES.

Wages, etc., of officers, seamen, and boys, coast guard and royal marines	£6, 079, 545
Victualing and clothing for the navy	2, 512, 706
Medical establishments and services	269, 410
Martial law	17, 892
Educational services	133, 023
Scientific services	86, 092
Royal naval reserves	287, 077
Shipbuilding, repairs, maintenance, etc.:	
Section I. Personnel	2, 674, 415
Section II. Matériel	5, 017, 700
Section III. Contract work	7, 738, 150
Naval armaments	3, 420, 175
Works, building, and repairs at home and abroad	1, 128, 000
Miscellaneous effective services	381, 663
Admiralty office	303, 300
Total effective services	30, 049, 148

The following notes and extracts are from the statement by the First Lord of the Admiralty in explanation of the budget:

ADMINISTRATION.

The Admiralty has been expanding concurrently with the general expansion of the navy, and it is one of the most important duties of the board to supervise this expansion and to see that it takes place on sound lines. The dangers to be guarded against are excessive centralization, imperfect devolution of responsibility for details on subordinate officers, and the consequent overburdening of the higher officials who ought to reserve their strength for the main direction of administration, the consideration of principles, and improvements in the service. Most important of all, the development of the peace administration must be on such lines as make for efficient war administration. The board are keenly alive to the importance of this aspect of the question.

Considerable changes have taken place, or are in contemplation, in connection

with the controller's department. The general object which the board have had in view has been, as far as possible, to relieve the controller of all work not directly connected with the construction, reconstruction, and repair of ships, or the management of dockyards, and similarly to relieve the director of naval construction of all work not directly connected with the designing of ships and the superintendence of their construction in accordance with the designs. The authority of admirals superintendent of dockyards has been increased and their power enlarged, with the object of diminishing the number of references to the Admiralty.

PERSONNEL.

It does not appear to be fully understood by the service or the public generally that by the constitution of the board of admiralty the sole responsibility for promotions rests with the first lord, who, however, in the performance of the difficult and invidious but most necessary task of selection is accustomed to consult his naval colleagues and to discuss freely with them the comparative merits of the different officers eligible for promotion. I mention this because the average age of captains on promotion to the rank of rear-admiral has considerably increased of late years, and I consider that the absence from the flag list of a due proportion of younger officers is a matter of serious moment, and because I recognize that I am specially responsible for devising a remedy for the future.

Much attention has for some time past been paid by writers on naval matters to the question of the education of the officers of the navy. I am glad that this is so, because, important as the matériel of the navy is, the personnel is much more important. Thoroughly efficient officers and men will always make the best of any matériel intrusted to them. No ships, however excellent, will effect anything in the hands of an inefficient personnel. The criticism leveled at the present system of training officers in general is that it is not based on one continuous systematic plan, but is the result of a series of independent decisions; in particular it falls under two heads—that the officers are not sufficiently at sea, and that the subjects of the courses at Greenwich are not well chosen or arranged. As regards the general criticism, it is of course true that the present system of education is, like everything else in the navy, a gradual growth of time, and not a scheme of one man or of one committee; but I do not admit that it is not coherent. Proficiency in foreign languages certainly requires further encouragement, but at a period when lieutenants are constantly employed it is difficult to provide opportunities for study abroad after a young naval officer has once entered the service. Officers who have qualified have been and are being appointed as interpreters and receive extra pay as such.

Last year an advanced course in naval history, strategy, tactics, and international law was commenced at Greenwich for the senior officers of the fleet. If the minds of naval officers are as a result turned to a more constant and thorough study of naval problems it will have fulfilled the main object the board had in view in its foundation.

The numbers voted for the current year were 118,625 active service ratings. It is expected that the establishment will have been reached by the end of the financial year as recruiting has been good. The numbers proposed for next year are 122,500. The increases will consist of the following ranks and ratings:

Officers	266
Warrant officers	143
Seamen	1,500
Artisans and electricians	250
Engine-room artificers	150
Stokers	1,000
Miscellaneous	400
Boys (shipwrights and coopers)	166
Total	3,875

The personnel of the fleet is to be as follows:

Flag officers	16
Commissioned officers	4, 048
Subordinate officers	764
Warrant officers.....	1, 641
Petty officers and seamen	78, 522
Boys (service)	3, 700
	88, 691
Coast Guard, officers, and men.....	4, 200
Marines (afloat and "ashore") officers and men	19, 589
	112, 480
Total for sea service	10, 020
Total for other services	122, 500
Total personnel	

THE ROYAL MARINES.

The establishment of the Royal Marines was raised on April 1, 1901, from 18,800 to 19,800, to meet which increase and to replace waste, 3,541 recruits were raised. The corps is now within a small number of its new establishment, and notwithstanding the continued waste caused by the disturbing elements in the recruiting for the last year, there is every prospect of the full number being reached by the 31st of March.

NAVAL RESERVES.

The increase of the reserves has not kept pace with that of the active-service ratings, and it has been decided to appoint a committee to consider how far the manning of the navy may be supplied and the active-service ratings supplemented by naval reserves.

The establishment of 1,500 officers, R. N. R., is complete, comprising—

Lieutenants	482
Sublieutenants	494
Midshipmen	524
Total	1, 500

There are 378 qualified candidates on the list of applicants. The numbers now undergoing naval training in H. M. ships are:

	12 months' training.	G. and T. training.
Lieutenants.....	20	7
Sublieutenants.....	53	9
Midshipmen	5	4
Total.....	78	20

Two hundred and sixty-one officers on the active list have already undergone this training and are in receipt of training fees.

The establishment of engineer officers is also complete, viz:

Senior engineers	70
Engineers	179
Assistant engineers	151
Total.....	400

There are 55 qualified candidates on the list of applicants for appointment.

The instructional courses for these officers continue to be held three times a year for three months each. The number allowed per annum has been increased from 18 to 54.

The following officers have completed, or are now undergoing, courses:

Senior engineers	16
Engineers	45
Assistant engineers	12
Total	73

The number of seamen, R. N. R., borne on the 31st of December, as compared with those voted for 1901-2 and former years, are:

Class.	Voted, 1901-1902.	Borne.		
		Dec. 31, 1901.	Dec. 31, 1900.	Dec. 12, 1899.
Qualified seamen, first class (O.S.)	11,700	{ 3,485	2,937	2,080
		{ 7,106	7,978	8,921
Seamen, second class (O.S.)	11,300	{ 4,973	4,218	3,406
		{ 5,063	5,996	7,555
Total	23,000	20,627	21,129	21,962

The numbers, which had been gradually falling off, have begun to increase since August, 1901. This increase may be attributed to the new conditions of enrollment and naval training referred to last year, which came into force the 1st of July last, and which have good promise of being successful in increasing the popularity of the service.

Eight hundred and twenty-seven R. N. R. men were embarked for naval training during the year, and 529 were actually embarked at the beginning of this year.

The number of firemen borne compare as follows:

December 31, 1901	3,714
December 31, 1900	3,530
December 31, 1899	3,494

An alteration in the rules was made in 1901, whereby firemen need not serve actually in sea-going ships after their first period of five years' enrollment. Many men get employment as firemen in river steamers, tugs, factories, etc., who are now able to reenroll under the new conditions. The increase in numbers which has recently taken place is attributed to this, and provision has been made for 3,800 next year.

TERMS OF REFERENCE TO NAVAL RESERVES COMMITTEE.

(1) How far are the present systems in force for the provision of reserves satisfactory or capable of extension, as to officers of all branches, seamen, stokers, marines, sick-berth staff, and other ratings?

(2) How far can a naval volunteer movement be utilized to contribute toward the manning requirements of the war fleet?

(3) Is it feasible to form some auxiliary branch of the Royal Marines which could be made available for service on shore or afloat in time of war?

(4) To what extent and in what manner can colonial naval reserves be utilized to contribute toward the manning requirements of the war fleet, bearing in mind that on the outbreak of war the men in reserve would be in the colonies, and that as at present arranged the ships in reserve that they could help to man would, with some few exceptions, all be in home ports?

(5) Are there any other methods besides those hitherto mentioned which can be recommended for the formations of naval reserves?

(6) What training would be required for the reserves of the different classes, under what conditions should it be given, what staff of instructors and equipment material would it entail, and how should the cost be borne?

(7) What should be the pay and allowance and conditions of service of the reserves of different classes?

(8) How far is the number of active-service ratings required to man the war fleet at any given time affected by—

(a) The total number of ships in commission in peace?

(b) The number of ships in commission in peace which would not in the opinion of the admiralty be of serious value in time of war?

(9) Generally, whether and how, consistently with efficiency, naval reserves can be more fully utilized to supplement the active-service ratings in peace or in war?

(10) What would be the cost of any recommendations made, and how will that cost compare with an alternative increase of active-service ratings?

TRAINING SHIPS.

It has been decided not to build ships for the establishment of a new training squadron. If the board had believed that service in masted ships was essential for the proper training of the seamen of the fleet, a new squadron of sailing ships would have had to be provided, however difficult and inconvenient. I desire that there should be no ambiguity on this subject, and therefore state plainly that the board do not consider exercise with masts and yards to be essential for the proper training of the officers or seamen of the fleet, and that henceforth it is abandoned as a necessary part of their education after they have left the training ships. The brigs are retained for the boys in connection with the training ships, and the "cruiser" is used in the Mediterranean as an adjunct to the training of the seamen, because practice in masts and yards is excellent both for mind and body. This no one doubts; the question is, Is it an essential factor in the sea-training of a modern naval officer or seaman in order to make him the perfect instrument of warfare which he should be? It is that question which the board answers in the negative, and the occasions on which, in their opinion, such training is permissible and valuable are those on which it does not displace any part of that training which is essential or conflicts with the exigencies of the service in the manning and commissioning of fighting ships. If I am asked what is essential, I would reply all sea knowledge which is necessary for the management of modern vessels of war and their boats under all conditions, and gunnery and torpedo work in all its branches. Further, I believe that the training of the modern seaman should more and more adapt itself to the peculiar characteristics of the ships he has to man. As oars gave place to sails, so sails have yielded to engines and timber to metal. The training of the seaman should, therefore, be directed toward a knowledge of the structure and machinery of a modern man-of-war, and capacity and handiness to deal with and repair it. Gunnery, however, is the most important of all, and in gunnery the emulation between His Majesty ships is becoming very keen. But our seamen and marine gunners must be able to shoot straight at long as well as at medium range; they must be able to hit their target with the guns trained in any direction in which they will bear; and, above all, they must never become fair-weather gunners. Emulation, therefore, must not be allowed to lead to a restricted selection of conditions and weather for target practice.

DISTRIBUTION OF THE FLEET.

The distribution of the commissioned fleet among the various stations of the globe is a product of time. The present distribution has been gradually evolved in accordance with the peace as well as the war requirements of the Empire. The question

of the future composition of the Australasian squadron will be discussed with delegates from the Australian commonwealth and New Zealand during the course of this year. The Pacific and South American squadrons are being reduced to 3 cruisers and 1 sloop, and 1 cruiser and sloop, respectively. At home the cruiser squadron is now at its complete strength in numbers, but during the year its strength in quality will be augmented by the substitution of armored for two of the present protected cruisers.

To this and the experience which will be gained from its work, both by the officers and men, the board attach great importance; it is fully recognized that the work which our cruisers will have to perform in war requires constant practice and study. The maneuvers in the Channel last year significantly marked this fact, and the idea of the subsequent exercises in the Mediterranean lends itself to a continuance of the lessons then taught. In respect to the battleships, the policy of the board is gradually to change the composition of the home, Channel, and Mediterranean squadrons, so that, like the China squadron, they shall be composed of homogeneous classes of battleships. While the recurrent cruises of the home, Channel, and cruiser squadrons will take place as usual, the maneuvers of this year will not take place in home waters, but will be carried out by a combination for the occasion of the Mediterranean fleet with the Channel and cruiser squadrons.

FRANCE.

The projected budget for 1902, as submitted to the French Chamber, amounted to 312,097,951 francs (\$60,234,904), an apparent reduction of 15,594,579 francs over that of last year, but as the defense of the coast and the colonies has been transferred, with its budget of 27 million of francs, to the ministry of war, there is in reality an increase of about 11.5 millions of francs in the estimates.

The amount estimated for shipbuilding in 1902 was 121,750,000 francs, of which 90½ millions of francs was intended for new ships.

The ships building and proposed in 1902 are as follows:

	To be completed.		To be continued.		Total.	Pro-gramme, 1902.
	Government.	Contract.	Government.	Contract.		
Battleships	2	.....	1	1	4	4
Armored cruisers.....	6	2	3	3	14	2
Cruisers, first class.....	1	.....	.....	.....	1	.....
Destroyers.....	3	2	5	18	23	7
Submarines	10	.....	18	.....	28	13
Torpedo boats, first class.....	2	24	1	.....	27	16

Four battleships were to have been laid down in 1902, as given above, but of these, three, A12, A13, and A14, have been struck from the list by the budget committee. They are inserted in the budget as a matter of form. Only one of the four will be commenced this year, but the material for the other three will be bought this year, so they can be commenced next year.^a

^a On Mar. 8, by a vote of the Chamber, the ships struck from the list by the committee, were reinserted.

On July 10, it is reported that the new French Minister of Marine, M. Pelletan, has countermanded the order for three large battleships given by his predecessor.

Thirteen submarines are to be placed on order, with the understanding that they shall not be commenced until next year. The definite programme, then, for 1902 is 1 battleship, 2 armored cruisers, 2 destroyers, and 16 torpedo boats, together with material for A12, A13, A14, and the submarines.

The fact that the Government has been swayed both in regard to the matters of total expenditure and ship-building programme is significant of a change of naval policy, and a new direction may be given it.

With this in mind the following table, showing the proposed programme indicated in last year's estimates as compared with the proposed programme indicated in this year's estimates, is interesting.

New ships contemplated as being completed in.....	1902.		1903.		1904.		1905.		1906.
Class.	According to the budget of 1901.	According to the budget of 1902.	Budget 1901.	Budget 1902.	Budget 1901.	Budget 1902.	Budget 1901.	Budget 1902.	Budget 1902.
Battleships		2					2	3	3
Armored cruisers	7	8	4	7	1	1	1	3	
Cruisers		1							
Submarines	7	10	3	14		9		12	14
Destroyers	8	5	16	17	2	2		2	6
Torpedo boats	15	26	5	16		26		39	63

The above table is not an exhibit of a definite building programme. Some of the figures are of ships already building, others of ships proposed but already practically eliminated from the programme of this year (1902). The figures, however, are the tabulated results of the ideas (naval policy), at the time of submitting the estimates, of those charged with the development of the country's naval defense, and a difference in opinion between this year and last, for future construction indicates the difference of policy as to what is best. The table notes a marked change in the development of the submarine and torpedo element of the national defense.

The building programme adopted by France in 1900 provided for the building before January 1, 1907, of the following vessels: Six battleships, 5 armored cruisers, 28 destroyers, and an indefinite number of seagoing torpedo boats and submarines. As a whole, this programme is being carried out, but its continuity from year to year is very uncertain.

By an analysis of the budgets is demonstrated the extraordinary difference in cost of shipbuilding at various French ports, shown as follows:

Port.	Cost of building per ton.	Port.	Cost of building per ton.
	<i>Francs.</i>		<i>Francs.</i>
Brest	141	L'Orient	220
Cherbourg	144	Rochefort	160
Toulon	170		

NOTE.—These disparities are at least explained in part by the fact that different classes of ships are built at various ports, and that the smaller vessels are comparatively more expensive to build than the larger ones.

PERSONNEL.

The French navy is short of officers and is suffering from stagnation in promotion.

During the past two years there have been many efforts on the part of the French ministry of marine to increase the number of officers. The constant increase in the number of ships has already resulted in a dearth of officers for vessels already in commission. The condition of those officers in the grade of lieutenant (*lieutenant de vaisseau*) is one of particular hardship, those at the top of the list in October, 1901, being about 47 years of age and having served eighteen years in that grade.

With reference to this, a writer in *La Yacht* comments as follows:

"We believe that the situation is grave. Our corps of officers is certainly one of the best instructed in Europe, lacking neither valor nor technical value, but it is impossible to misunderstand the heaviness of spirit which tends to extinguish that sacred fire without which no military service is possible. The officer who does only what is required of him by routine will never lead our fleets to victory. In the navy self-denial is necessary—a sacrifice of oneself that we can only hope to find in a service in which men are satisfied with their careers."

A bill has been introduced for the purpose of establishing the grade of "*capitaine de corvette*," corresponding to that of lieutenant-commander, and to fix the number of this grade at 150, but it is not believed that it will pass. Under these circumstances little relief has been given by the passage of a law creating a fixed residence corps, which enables the minister of marine to practically obtain an increase of 20 each in the grade of lieutenants and commanders. A translation of this law follows:

LAW CREATING LIST OF NAVAL OFFICERS IN FIXED RESIDENCE.

ART. 1. There is hereby created a special list of commanders and lieutenants to be known as "fixed residence list."

ART. 2. Commanders and lieutenants who accept employment on fixed residence list renounce in advance all advancement or promotion in general service by the simple fact of their accepting these special duties, except in the case noted in article 4.

ART. 3. Lieutenants on the fixed residence list may be advanced to the grade of commander in the same list, in the same manner as is effected in the general service, half by seniority and half by selection: Provided, Only one-half of the vacancies shall be filled from the lieutenants of the fixed residence list, the other half being filled by appointments from commanders in the general service.

ART. 4. A lieutenant on the fixed residence list can be promoted from that grade to the grade of commander by seniority or by choice only after he shall have become senior in date to all the lieutenants on the general service list.

In case no lieutenant fulfills this condition, the list of commanders on the fixed residence list may be filled until the condition may be realized by a commander taken from the general service list and given temporary duty on the fixed residence list.

ART. 5. Commanders and lieutenants on the fixed residence list shall take rank among themselves according to the date of their promotion to the grade of commander or lieutenant in the general service. Lieutenants on the fixed residence list promoted to commanders on the same list will take rank according to the date of their promotion to said superior grade.

ART. 6. Commanders and lieutenants on the fixed residence list can not be restored to the general service list.

ART. 7. The age limit for admission to the retired list of commanders and lieutenants on the fixed residence list shall be: For commanders, 60 years; for lieutenants, 58 years.

ART. 8. The pay of commanders on the fixed residence list remains the same as that of commanders in general service on shore duty.

Lieutenants on the fixed residence list will receive the longevity increase of pay allowed to lieutenants in general service on shore duty. Two such increases may be made. The first shall be 750 francs and the second 800 francs.

ART. 9. The following articles are applicable to officers on the fixed residence list: Third, fourth, and last paragraphs of article 8 of the law of June 10, 1896; the finance law of April 15, 1898; articles 9, 10, 12, 13, 14, 15, and 33, and paragraphs 2, 3, and 4 of article 38; and Title III (officers of reserve) of the law of June 10, 1896.

ART. 10. The number of commanders on the fixed residence list is fixed at 20; for the first formation of this list there shall be established by ministerial decree herein provided for the various stations and duties for said officers, according to the number to be appointed; the number of lieutenants on the fixed residence list is also established at 20.

ART. 11. A ministerial decree shall determine the special duties which shall devolve upon the commanders and lieutenants on the fixed residence list, as well as all other matters of detail.

In accordance with article 11 of the law of December 31, 1901, the minister of marine issued the following decree January 9, 1902:

DECREE.

ARTICLE 1. The employment of commanders and lieutenants on the fixed residence list (*en residence fixe*) is accorded to officers of corresponding grades in the general service upon their application. The transfer from the general service to that of fixed residence, as also the promotions of lieutenants on this last list to the superior grade will be made by decrees published in the Journal Officiel.

ART. 2. Lieutenants, in order to be placed on the "fixed residence" list, must have completed eight years in that rank, of which four years shall have been sea service in said grade.

ART. 3. The increase of pay provided for in article 8 of the law of December 31, 1901, may be accorded by the minister of marine upon the recommendation of the

naval authorities—the first after three years of service on this list, the second not less than four years after the allotment of the first. These recommendations for increase, made by the authorities charged therewith, and accompanied, if need be, by a “list of preferences,” will be forwarded to the minister with the annual reports.

ART. 4. The duties devolving upon commanders and lieutenants on the fixed residence list are as follows :

Employment.	Cherbourg.	Brest.	Lo-rient.	Roche-fort.	Toulon.	Paris.	Al-giers.
COMMANDERS.							
Hydrographic service:							
Chief of sailing directions						1	
Nautical instruments						1	
Meteorological division						1	
Submarine defenses						1	
Inspector of electro-semaphores	1	1	1	1	1		1
Commandant of receiving ship (or barracks)	1			1			
Senior aid to commandant of receiving ship (or barracks)		1	1		1		
Subdirector of movements of the port	1	1			1		
Groupe flotte (general police, fatigues, etc.)		1			1		
Total	3	4	2	2	4	4	1
LIEUTENANTS.							
Hydrographic service (sailing instructions)						2	
Submarine defenses						1	
Fixed defenses (mines, etc.)	1	1	1	1	1		
Direction of the movements of the port	1	1	1	1	1		
Equipment of officer of barracks	1	1	1		1		
Archives, charts, and plans		1			1		
Secretary of the torpedo commission					1		
Total	3	4	3	2	5	3	

The question of the budget is the obstacle to service legislation. A reform accomplished by M. Lanessan is the separation of the purely military administration of the ministry of marine from the bureaus of construction and supplies. Hitherto the flag officer, who performed the functions of chief of the general staff of the navy, was at once director of the naval and civil cabinet of the minister, and executive chief of the officers and civil employees of the whole department. This extraordinary power and authority formerly enjoyed by the chief of staff has now been curtailed. The chief of staff is no longer the head of the minister's cabinet, and his functions have been subdivided into sections, each under a separate chief.^a The chief of staff is now intrusted with all that concerns the discipline, instruction, and mobilization of the fleet. The administration of the services of armament, equipment, and supplies forms a separate section under control of a flag officer, directly responsible to the minister. Matters pertaining

^aSince the accession of M. Pelleten, the new minister of marine, there are indications of another change in the organization of the French general staff. Details of this change are not yet definitely known.

to artillery and gunnery are placed in a third section. Torpedo boats and submarines form a fourth department. Naval construction forms a fifth department. All these functions had hitherto been grouped together in one administration under the exclusive control of the chief of staff.

The minister of marine has reorganized the naval coast defenses. Instead of the director of submarine defenses having control of torpedo boats, each port is to have an independent authority, amenable solely to the maritime prefect, and through him to the minister of marine. The supply of lieutenants and ensigns for torpedo boats and submarines being insufficient, the master pilots are to have the command of some of the torpedo boats. Hereafter torpedo boats are to be grouped in pairs, so as to assist each other in search of the enemy. The first torpedo boat of each group is to be under the command of a lieutenant or ensign, and the second under a master pilot.

At each torpedo station the force is to be divided into two parts, the first kept fully manned, while the second will only have a crew sufficient to take proper care of the vessels. Only after contact with the enemy by the first division will it be followed up by the second division. The crews will be required to spend three months alternately on board the reserve torpedo boats and on board the active ones, the first division always to have a mobilization of at least five days at the end of each period of three months. Measures are to be taken to test and put on record each month the actual condition and endurance of the torpedo boats and submarines at each station, and also to register their sea speed. Numerous workshops are to be constructed all along the coast, to effect temporary repairs. This new organization is highly spoken of by the naval experts, and is expected to insure an extraordinary efficiency and development of naval coast defenses along the whole length of the French seaboard, on the Atlantic as well as on the Mediterranean. The whole coast defense will thus constitute one separate department, intrusted to a vice-admiral.

Another reform effected is the new strategic grouping of the French naval forces in the East. The four hitherto independent naval divisions of the extreme East have been abolished, and all placed under one command, called the naval force of the eastern seas. The vice-admiral intrusted with this important fleet will have two rear-admirals under his orders, and the three principal stations of his force are Saigon, Diego-Suarez, and Noumea.

A modification of the law of the *inscription maritime*, reducing the period of effective service, has been proposed. This period of effective service, which has a fixed maximum of five years, has seldom been enforced to its full limit. Recently, owing to events in China, it was fifty-six months. It has often been much lower. The proposed legislation would reduce it to thirty-six months. Owing to

numerous modifications recently introduced in the manner of recruiting, which bring in artisans and others outside, this, it is believed, will produce a sufficient number of men. When the proposed programme for the fleet has been carried out 80,000 men will be required, but the "*inscription maritime*," even with the reduced period, will give, it is estimated, a surplus of 19,000 men.

Petty officers' schools are being established by large cities, cooperating with the navy department. These schools are to prepare special petty officers in gunnery, torpedoes, etc.

The organization and status of the engineer corps is a prominent question at the present time, and a commission has been appointed to study the questions relating thereto.

GERMANY.

The estimates for 1902, as submitted to the Reichstag, amounted to 209,082,089 marks, an increase of 12,347,917 marks over last year's estimates.

Of this the amounts estimated for certain items are as follows:

	Marks.
New ships to be built.....	13, 720, 000
Ships building	41, 451, 000
Repairs and reconstruction.....	9, 925, 000
Ersatz—New ships built to replace old ones, not included in programme.	10, 070, 000
Extension of navy-yards and plants	7, 366, 560
Armament (guns, 26,006,000 marks; torpedoes, 4,230,000 marks).....	30, 236, 000

The estimates contain a reduction in the amounts proposed for armor. It is stated that this reduction is due to the continuity of the building programme, its steady demand for armor allowing the manufacturers to sell cheaper than could be the case were the demand unsteady, and is not due to any especial improvement in the cost of manufacture.

First appropriations occur for two battleships, one armored cruiser, and three small cruisers.

By reason of duties of international representation, unusually high expenses are frequently occasioned to war ships and naval garrisons, which the persons in question can not pay out of their regulation allowances. The budget for 1902, therefore, provides a special fund out of which allowances for these purposes are to be granted. Based on the experience of the last few years, the sum has been fixed at 8,000 marks (\$1,904).

The increase in the German navy in both personnel and material has been systematic, steady, and rapid. There is little doubt that the compliance of the Government and people with the well-known desire of the German Emperor for a strong navy is due, to a large extent, to the influence of the German navy league through its well-directed

efforts toward creating a positive and lively interest in the navy on the part of the people.

The efforts of the league have been directed with more than ordinary ability, and its influence, as the result of its efforts, could only be entirely satisfactory to those concerned in its direction.

A law passed April 10, 1898, provided for an increase in the fleet, the increase to be completed in six years. The strength of the fleet as contemplated by this law was attained in practically one-half of the proposed period, and in January, 1900, the increase of the fleet was again before the Reichstag, with the result that a considerable addition to the fleet was authorized in June of that year. The building programme of this authorization was to cover a period originally intended to extend to the year 1916. The fact that the increase authorized by the law of 1898 was carried out long before the expiration of the period contemplated, led the council to refrain from definitely fixing the year 1916, but to build as financial and other circumstances would permit; in other words, to complete the programme authorized in 1900 as rapidly as possible. This programme (1900) is now within a few years of completion, and it is highly probable that the actual material strength in number of ships, without counting those over the prescribed age, will be reached by 1908, if not in 1907.

By counting vessels still serviceable, but beyond the efficient age limit, the prescribed strength could probably be reached in at least three years.

TABLE I.

Building programme.	Battle-ships.	Armored cruisers.	Small cruisers.
Total required by law of 1900.....	38	14	38
Built, building	29	11	30
Remaining to complete programme.....	9	3	8
Authorized in 1902-1903 budget.....	2	1	3
Yet to be authorized to complete the programme of 1900.....	7	2	5

BATTLESHIPS.

In addition to new construction authorized, old ships were to be rebuilt where the character of the ship rendered such rebuilding worthy of the expenditure, while ships too old for rebuilding were to be replaced, such substitution or replacement not to interfere with new construction required to bring the fleet up to the strength required by the law of 1900.

Of the list of battleships, those of the *Sachsen* class, four in number, originally launched between 1877 to 1880, were reconstructed between 1895 and 1898, while six of the *Siegfried* class, launched 1889-1893, are being reconstructed under appropriations originating in the 1901-

1902 budget. This year's budget, 1902-1903, contains a first appropriation for the reconstruction at a cost of \$200,000 each of the four ships of the *Brandenburg* class. These ships were launched in 1891-92.

LARGE CRUISERS—SMALL CRUISERS.

The same process of substitution and replacement, independent of new construction, is carried on in these classes of vessels, the whole being the effective operation of an extremely well-considered plan to obtain an effective, well ordered and equipped fleet, at a period about eight years earlier than contemplated by the scheme as shown in the budget for 1900.

The budget of this year does not mention in the list of ships credited as existing under the law the armored ships (once battleships) *Kaiser* and *König Wilhelm*, both of which are still effective and until recently in commission as large cruisers, but refers to the new Ersatz^a already building for these. By counting these the prescribed strength in large cruisers is really reached, being 14 at present.

The small cruiser *Zieten* is not mentioned in the list of small cruisers, but only her substitute.

The special-service ships *Marie*, *Sophie*, *Carola*, *Olga*, and *Nixe* are all in commission and should be classed as small cruisers. This would bring the total number of small cruisers to 38.

The list of ships given in the budget does not comprise the whole of the German navy, but the bulk of its fighting strength. In addition, there are small craft, including torpedo craft, special-service vessels, and about 17 coast-defense and seagoing gunboats of about 1,000 tons displacement.

Of the torpedo divisions contemplated, 16 in all, only 2 divisions yet remain to be authorized, the construction in this element being far ahead of the programme.

Taken as a whole, the position of the German navy is that of equality with equal number of vessels in other navies, where ships are not considered ineffective simply because they are so many years old.

When the present shipbuilding programme expires with the authorization of the last of its ships, in 1904, it is the intention to introduce into the Reichstag those clauses of the bill which were rejected in 1900. This will call for 6 large cruisers and 7 small cruisers and a corresponding increase in personnel.

DEVELOPMENT OF THE PERSONNEL OF THE GERMAN NAVY.

The figures of the following analysis are taken from the budgets 1897-1902. While the personnel, as actually borne on the navy lists

^a New ships built to replace old ones. In contradistinction to entirely new or "increase" construction.

for the various years, may not coincide exactly with that given here (which is that appearing in the budgets), it approximates closely enough to allow the budget figures to give an accurate idea as to the progress of the German development of naval personnel.

The law of 1900, authorizing the existing programme of construction, contemplated in 1920 a personnel as shown by the following table:

TABLE II.

Grade.	Num-ber.	Grade.	Num-ber.
Flag officers	32	Ensigns.....	304
Captains	102	Cadets.....	140
Commanders.....	224	Engineer officers	427
Lieutenant-commanders.....	455	Medical officers.....	341
Lieutenants.....	647	Accountant officers.....	234
Lieutenants (junior grade).....	628	Rank and file	54,920

The following tables from the budgets show the development of the personnel as shown by the estimates for each year:

TABLE III.—*Total personnel.*

Grade.	Budget year.					
	1896-97.	1897-98.	1899.	1900.	1901.	1902.
All officers, commissioned	959	1,013	1,118	1,195	1,283	1,394
Sanitary personnel.....	116	122	142	153	164	175
Warrant officers.....	897	952	1,119	1,206	1,306	1,426
Petty officers.....	4,172	4,437	5,193	5,613	6,241	6,824
Men.....	14,992	16,178	18,079	19,037	20,744	22,289
Boys.....	600	600	1,000	1,000	1,300	1,300
Total personnel	21,736	23,302	26,651	28,204	31,038	33,408

TABLE IV.—*Officers.*

Grade.	Budget year.						
	1896-97.	1897-98.	1899.	1900.	1901.	1902.	1920.
Flag officers.....	13	13	15	16	17	18	32
Captains.....	43	46	48	51	54	57	102
Commanders and lieutenant-command- ers.....	80	84	93	100	109	119	224
Lieutenants.....	164	176	185	194	206	220	455
Lieutenants (junior grade).....	242	254	278	296	320	348	647
Ensigns.....	183	191	207	219	235	253	628
Midshipmen.....	167	167	207	270	326	401	304
Cadets.....	70	70	120	155	200	200	140
Engineer officers.....	90	102	128	144	159	189	427
Medical officers.....		130	142	153	164	175	341
Accountant officers.....		95	104	112	119	134	234

TABLE V.—*Analysis of the foregoing table, showing annual increase in each class.*

Grade.	Annual increase for the years below.					Total increase 1898-1902.	Average annual increase 1898-1902.	Average annual increase from 1900.	Annual increase from 1900 as contemplated by law of 1900.
	1898.	1899.	1900.	1901.	1902.				
Flag officers		2	1	1	1	5	1	1	1
Captains	3	2	3	3	3	14	3	3	2
Commanders and lieutenant-commanders...	4	9	7	9	10	39	8	9	9
Lieutenants	12	9	9	12	14	56	11	12	13
Lieutenants (junior grade).....	12	24	18	24	28	106	21	23	18
Ensigns	8	16	12	16	18	70	14	15	20
Midshipmen		40	63	56	75	234	47		
Cadets.....		50	35	45		130	26		
Engineer officers	32	26	16	15	30	119	24	20	14
Medical officers		12	11	11	11	45	11	11	9
Accountant officers		9	8	7	15	39	10	11	9
Warrant officers.....	55	167	87	100	120	529	106	110	
Petty officers	265	756	420	628	583	2,652	530	606	
Men	1,186	1,901	958	1,707	1,545	7,297	1,259	1,626	
Boys.....		400		300		700	140		
Total personnel ...	1,468	3,349	1,553	2,834	2,370	11,574	2,515	2,602	

TABLE VI.—*The executive elements of the fleet and navy-yards.*

Grade.	Date of budget.					
	1896-97.	1897-98.	1899.	1900.	1901.	1902.
Line officers (excluding cadets) ^a	749	785	852	905	974	1,054
Cadets.....	237	237	327	425	526	601
Engineers	90	102	128	144	159	183
Rank and file ^b	16,461	17,760	20,846	22,174	25,377	26,679

^a From 1897-1902 there were on active duty an average of 29 retired officers. These are included in this list.

^b Rank and file in this case includes the personnel of the sailor division, boys, the deck, engineer, and special personnel of the dockyard division, and torpedo division. It excludes the seamen artillery, marines, clothing, officers, medical department, ordnance corps, paymasters, and the technical elements of the mining, torpedo, and surveying branches. It approximates the controlling naval elements of a flexible sea force pure and simple, as contrasted with coast defense elements.

Analysis of the foregoing table.

LINE OFFICERS.

Number:

1902	1,054
1897	749
Increase between dates given	305
Average annual increase	61
1902	1,054
1900	905
Increase between dates given	149
Average annual increase	75
Annual increase contemplated in programme of 1900	60

MIDSHIPMEN AND CADETS.

The cadets are more than doubled in number, having been increased from 237 to 601.

ENGINEERS.

Number:

1902.....	183
1897.....	90
Increase between dates given	93
Average annual increase	19
1902.....	183
1900.....	144
Increase between dates given	39
Average annual increase	19
Annual increase contemplated in programme of 1900	14

RANK AND FILE.

Number:

1902.....	26, 679
1897.....	16, 461
Increase between the dates given	10, 218
Average annual increase	2, 044
1902.....	26, 679
1900.....	22, 174
Increase between the dates given	4, 505
Average annual increase	2, 253

From the foregoing it is estimated that the elements of personnel required by the programme of 1900 will be completed at the same yearly increase as given above (1900-1902) in the following years: Line officers in fourteen years, or by 1916; engineers in thirteen years, or by 1915; rank and file in twelve years, or by 1914.

The building programme of the German navy will be practically complete in 1907. The foregoing figures show that the corresponding numbers in personnel will not have been attained so soon, but will be reached by 1915 at the latest.

The increase of the number of cadets from 237 in 1898, to 601 in 1902, gives promise of the complement of line officers being attained at a much earlier date than 1915.^a

It must also be borne in mind that military (naval) service in Germany is compulsory, and that men who have completed their terms of active service with the fleets and have passed into the reserve are all well-trained men.

The coast defenses are being gradually transferred to the navy. In

^aThe German navy list for January, 1902, gives the following list of officers: Flag officers, 24; captains, 55; commanders and lieutenant-commanders, 119; lieutenants, 221; lieutenants (J. G.), 351; ensigns, 131; midshipmen and cadets, 727; engineer officers, 181; medical officers, 177; accountant officers, 121.

1901 about 3,700 officers and men were employed to garrison the whole of the works at Wilhelmshaven, Kiel, Bremerhaven, Cuxhaven, and Heligoland, and for the water defenses, such as submarine mines.

RUSSIA.

The total Russian naval estimates for 1902 amount to 98,318,984 rubles, an increase of 4,721,318 rubles over the estimates for 1901.

The items follow:

	Rubles. ^a
Central administration and port service.....	2,400,566
Schools (training service).....	1,128,633
Medical service and hospitals	1,215,063
Pay	5,789,149
Provisions	1,952,618
Clothing.....	2,916,078
Navigation.....	20,425,003
Hydrographic service.....	966,221
Marine artillery, torpedo service, electric lighting	11,468,339
Naval construction	25,637,517
Works and admiralty.....	5,740,523
Rent and maintenance of admiralty buildings and new construction	5,959,994
Missions	849,000
Gratuities and assistance.....	555,478
Contingent expenses.....	1,787,668
Installation and improvement of military posts.....	9,226,733
Credit for the needs of 1903	300,396

BUILDING PROGRAMME.

Reports indicate that this year's building programme contemplates 3 battleships and 2 armored cruisers. Since the adoption of this programme, it is reported that the promulgation of the Anglo-Japanese alliance has caused an appropriation by Russia for 4 battleships and 2 armored cruisers in addition to the regular programme. These ships will be built abroad if the capacity of the home yards will not admit of them being built there.

On January 1, 1902, by an order of the Czar, 2 additional "equipages" of 1,500 to 2,000 men each were established. One of these is to be assigned to the Black Sea division and one to the Far East, the latter to be known as the "Kvartoon Equipage."

AUSTRIA.

The total Austrian budget for this year amounts to 46,690,820 crowns, an increase of 3,200,000 crowns (\$649,600) over last year.

There is no increase in the personnel.

The programme for new construction proposes 2 Danube monitors and 5 patrol boats.

^a 1 ruble=\$0.515.

By the removal of obstructions to navigation in the lower Danube, it has become possible for foreign warships to advance into the upper Danube. For this reason the increase of the Danube flotilla, as noted above, is considered as an urgent necessity.

The following are among the most important chapters of the budget:

1. Pay.....	\$846, 741. 42
2. Wages and money for clothing	554, 045. 87
3. Service ashore.....	362, 629. 05
4. Service afloat.....	820, 995. 54
5. Institutions (including naval academy, library, hospital, school, hydrographic office, etc.)	96, 642. 21
6. Running expenses and repairs of ships and replacing old ships by new ones	2, 713, 003. 65
(This chapter includes \$1,238,300 under the head of "Building ships and engines," being installments for ships under construction.)	
7. Ordnance	239, 134. 00
8. Dockyard improvements	133, 707. 98
9. Special expenses of the navy	105, 423. 99
10. Pensions, etc	425, 386. 50

Under the head of "Extraordinary expenses" are additional items to chapter 5, above, and the following to chapter 6:

For the acquisition of a steel floating dock with appurtenances.....	\$203, 000. 00
Building ships and engines.....	1, 745, 800. 00
(Being \$81,200 for 2 new Danube monitors and 5 patrol boats, the balance for ships building.)	

Additional items to chapter 7, Ordnance:

Guns and ammunition for ships under construction.....	\$1, 083, 714. 00
Mines	20, 300. 00
Torpedoes and torpedo nets.....	36, 540. 00

Additional items to Chapter 8, Dockyard improvements:

Coal and torpedo-boat station, Teodo	\$28, 420. 00
Ammunition and powder magazine, Vallelunga	30, 856. 00
Magazine for mines	9, 338. 00
Monte Saline proving ground near Pola	5, 927. 60
Carrier-pigeon station in Dalmatia.....	1, 827. 00

JAPAN.

The Japanese naval budget for 1902-3 contains the following items, amounting to a total of 28,425,639.671 yen (\$12,155,968):

Ordinary expenditures:	Yen. ^a
Central office	179, 855. 570
Miscellaneous.....	21, 169, 198. 105
Total.....	21, 349, 053. 675

^aOne yen = \$0.498.

Extraordinary expenditures:	Yen. ^a
Civil engineering.....	82, 280. 500
Construction—repairs	40, 784. 000
Surveying	19, 128, 498
Naval expansion, ships, guns	5, 113, 782. 461
Construction materials, naval stations	30, 000. 000
Department of works.....	34, 317. 330
Gratuities	1, 200. 000
Charts and records (for sale).....	6, 000. 000
Expansion of Kure Arsenal.....	1, 557, 264. 980
Ordnance construction materials fund.....	191, 828. 227
Total.....	7, 076, 585. 996

A bill has passed to expand the Kure Arsenal and to establish a steel foundry for the purpose of producing armor plates. The expenses of this expansion are to extend over a period of four years. The first installment is included in the Kure item in the extraordinary expenses as noted above.

A new shipbuilding programme is being considered, but as yet has not been definitely promulgated. It is stated that this programme, for the six years commencing 1904, will comprise the construction of 4 battleships of 15,000 tons each, 2 armored cruisers of 9,900 tons each, 4 second-class cruisers of 5,000 tons each, 15 destroyers, and 50 torpedo boats.

ITALY.

The outlay for the year 1902-3 for the Italian navy will be 121,000,000 lire,^b but, deducting the charges for the mercantile marine and some other nonrelated matters, the estimate is reduced to 111,396,379 lire. The average strength of the personnel will be 1,855 officers and 25,000 men. A squadron will be maintained in the Mediterranean comprising 8 battleships and four armored cruisers, with 9 smaller vessels. There will be an ocean squadron of 8 vessels and a training division of 3 vessels, as well as 7 vessels on various stations. The Mediterranean Squadron will have full complement for a period of seven months. It is stated that the total value of the material of the Italian navy is 501,366,856 lire. A sum of 29,169,600 lire will be devoted to the construction and completion of the *Benedetto Brin*, *Regina Margherita*, *Francesco Ferruccio*, *Vittorio Emanuele III*, and *Regina Elena*, and to putting in hand 3 other first-class battleships. The sum named does not include 1,000,000 lire which have been assigned to the construction of the *Italia*. Four and a half million lire will be devoted to the purchase of coal, of which 130,000 tons will be acquired.

^a One yen = \$0.498.

^b One lira = \$0.193.

SWEDEN.

The Swedish naval estimates for 1902 amount to 10,461,982 crowns for the ordinary budget and 10,983,043 crowns for the extraordinary, showing an increase over the previous year of 2,331,027 crowns in the ordinary budget and a decrease of 2,439,062 crowns in the extraordinary.

The following are the principal items in the ordinary budget:

	Crowns, ^a
1. Ministry of marine	93, 400
2. Personnel of the fleet	3, 851, 740
3. Matériel	1, 685, 000
4. Ships in commission and instructional cruiser.....	1, 361, 900
5. Naval schools	53, 470
6. Medical department and hospitals	44, 000
7. Coast artillery.....	1, 479, 496
8. Divers' expenses.....	1, 479, 496
9. Mercantile marine.....	1, 688, 209

Out of the extraordinary budget, 8,932,765 crowns are devoted to the service of the fleet proper, of which 6,639,915 crowns are for war matériel; 280,000 crowns for the reconstruction of the monitors *Thor-dön* and *Tirfing*; 107,900 crowns for the conversion of certain torpedo boats into vedette boats; 1,206,000 crowns as the second credit for the guns and torpedoes of the battleships "A," "B," and "C;" 15,000 crowns for gunnery trials; 5,000 crowns for torpedo trials; 80,000 crowns for the purchase of reserve torpedo matériel; 50,000 crowns for the purchase of submarine mines; 50,000 crowns for boom matériel; 290,000 crowns for coal, and 105,000 crowns for clothing; these two last items being in connection with mobilization. In the credit of 6,639,915 crowns for war matériel are included the sums required for new ships, divided as follows: 1,835,865 crowns for the completion of battleships "A," "B," and "C;" 598,050 crowns as first vote for three first-class and two second-class torpedo boats, and a torpedo-boat destroyer; 2,813,000 crowns as first vote for the construction of a first-class battleship, and 181,000 crowns for a balloon ship. The admiralty has also entered into a contract for a 31-knot destroyer, to be of the most modern type, and to be provided with the necessary fittings for burning petroleum fuel. The vote for the personnel provides for an increase of 50 officers, 53 petty officers, 350 men, and 80 boys. This gives a total of 210 officers, 362 petty officers, 2,825 men, and 400 boys.

^a The crown = \$0.268.

VIII.

THE VITTORIO EMANUELE AND COMPARISONS OF MODERN BATTLESHIPS.

By Naval Constructor VITTORIO E. CUNIBERTI, Italian Navy.

[Translated in the Office of Naval Intelligence, from the *Rivista Marittima*.]

The five battleships of the *Vittorio Emanuele* type which Admiral Morin, minister of marine, has embodied in the budget submitted to the Chamber at its session of November 30, 1901, are to form a special naval division, homogeneous, powerful, and of great speed, which, flanked by the twelve fast destroyers which are about to be completed, will be able to cope with any enterprise hitherto beyond the power of our navy for lack of speed and homogeneity.

Having abandoned the system of building ships in pairs, like the *Emanuele Filiberto* and *Ammiraglio di Saint Bon*, or the *Regina Margherita* and *Benedetto Brin*, and adopted the English system of series, like the *Bulwark*, *Duncan*, and *Cressy* classes, we shall be able to attain better results, both partial and total, from the characteristic features of the new ships, which, if each stood alone or were joined with others of less speed, would not be able to bring out the total efficiency inherent in them.

It is therefore but natural that the characteristics of this new type form the subject of animated discussions in the Italian as well as the foreign press, that the objects to be attained by this group are being closely scrutinized, and that the ultimate results of this design are being doubted, in some cases even called improbable.

The leading criticisms in the technical press, in inquiring into the *fin-de-siècle* development of naval architecture in Italy, have for the most part been friendly to us, and the comparisons made abroad between our latest designs and those of other navies have in the final summing up been in our favor. But not all the critics have admitted the advisability of uniting the characteristics of the largest modern

battleships with the most salient features of the fastest armored cruisers built by some of the powers.

My intention is to point out in these pages everything of interest that has been said on the subject of our new design in lectures on naval matters, and everything that has been written in reviews and political and naval publications on this question, which is of the utmost importance to Italy, the first nation to inaugurate new methods in the solution of the complex problem of modern shipbuilding, including the composition of future fleets.

The principal lectures on this subject are those of Naval Constructor H. G. Gillmor, United States Navy, Lieut. Herbert W. Hope, British Navy, and Chief Engineer of Ordnance B. Sabath, Austrian Navy. The foreign periodicals which have discussed the question are *The Engineer*, *Schiffbau*, *The Nautical Gazette*, *Scientific American*, *Le Yacht*, *Marine-Rundschau*, *El Mundo Naval*, *La Marine Française*, *Ueberall*, *Le Petit Var*, *Revista General de Marina*, etc.

ABSOLUTE AND RELATIVE STUDIES.

In order to obviate any imputation of chauvinism I will begin by saying that different navies have different aims, and therefore the types of ships designed to attain them must likewise be different. Hence it would be unjust to assign absolutely to this battleship or that the temporary fame which may result from comparisons made of a few ships of different navies, since such ships, as a matter of fact, do not represent the total efficiency of the different navies.

An examination made in an absolute and not a relative manner ought to give much more reliable results as to the value of a given ship as part of the fleet to which it belongs and in which it occupies a certain position and cooperates in a certain manner with ships of other types in the attainments of predetermined aims.

But the question is so complex and at the same time so elastic that a good lecturer might be able to demonstrate in succession that the swift *Bogatyr* is the best ship in the world, that the slow *Bulwark* is ahead of all other modern ships, or, finally, that the famous *Katahdin* is the most formidable engine of warfare in a naval action.

Since we must therefore resort to relative studies—that is to say, to comparisons of different designs and different navies—I believe such comparisons would be more rational if they were confined to ships having similar aims, and perhaps also approximately the same displacement and character, thus obviating the danger of uniting cruisers and battleships, ships of 10,000 tons displacement and those of 16,000 tons, ships of a secondary navy and those belonging to the most formidable navy in the world.

A comparison of English ships of the *Royal Sovereign* type and those of the *Majestic* class or of the older ships of the *Majestic* type

with those recently built on the same lines is a study in evolution which is logical, reliable, and of great value. To extend the comparison to the latest ships of the *King Edward* type is somewhat more risky, because other factors bear down upon the scales, other quantities enter into the equation, such as constantly increasing displacement, entirely different armament, etc.; but any attempt to compare these first-class battleships par excellence with the gigantic cruisers of the *Cressy* type of 12,150 tons displacement or of the *Drake* class of over 14,000 tons displacement would be as futile as an attempt to render an equation homogeneous when it is not, or to compare, for instance, the advantages of possessing a saddle horse with those resulting from the use of a comfortable armchair at the theater.

But while some are fast and perilous and others very slow and safe, there may also be found among the variegated designs of modern English ships "half-breed" types which, halfway between the precarious 6-inch armor of some and the safe 8.7-inch armor of the larger ships, have a mean protection of 7 inches, which, however, is distributed in an objectionable manner, since it leaves almost one-third of the ship toward the stern unprotected.

These ships, the *Duncan* class, were chosen by one of the lecturers referred to^a as a design, or rather as a representative of the British navy, and we shall state later the reasons which in our opinion must have led to this rather unfortunate choice. At present we will confine ourselves to stating that it is not well in making comparisons to take a single design, because, as previously stated, it is rather difficult, especially in the great navies, for one type to embody in its characteristics the whole technical aspect of a navy.

TOTAL RESULTS AND RESULTS PER TON OF DISPLACEMENT.

But that is not all. Many systems of comparison of foreign navies have attempted to determine the military value of each ship as a whole instead of the value per ton of displacement. The total value of a ship is higher when her armor is thicker and wider, when her guns are more powerful, more numerous, better protected, better distributed, etc. But this tendency toward total supremacy has led to increasing the displacement of the *Royal Sovereign* class from 14,000 to 15,000 tons in the *Majestic* and still further in the *Formidable*, finally reaching 16,000 or 17,000 tons in the *King Edward* class.

Affected by the same mania, the United States went from the *Alabama* of 11,500 tons to the *Maine* of 12,300 tons and to the original *Rhode Island* class of 14,600 tons, and will probably reach 16,000 tons in the latest type, or perhaps that figure has already been exceeded, as would appear from the report of Mr. Long, Secretary of the United

^aLecture delivered at New York before the Society of Naval Architects and Marine Engineers, at its ninth annual meeting, November 14, 1901.

States Navy, submitted to Congress, in which the displacements of the future United States battleships and armored cruisers are fixed at 17,604 and 15,960 tons, respectively.

It is easy enough to increase the number of eggs when you enlarge the basket, and it is obvious that if the enormous displacements are left out of consideration in the comparisons, these ships which have such a high total military value should always hold the first place, with a larger number of points of merit than any others.

But we must also take into account the points of demerit. These are determined especially by two factors:

1. The speed, which is reduced, because the weight of the machinery becomes enormous when it is desired to keep the speed at the same height, or to increase it in the same proportion as the other factors, such as armament, armor, etc. Now, speed is certainly not a negligible factor, either in single combat or in squadron engagements, although some are trying to demonstrate the contrary.

2. The expense required to build a division of an aggregate of about 50,000 tons, which with the same total and final results may consist of three of the largest ships of 17,000 tons each, or of four ships of 12,624 tons each, or finally of six ships of 8,500 tons each. Few of the lecturers and compilers of comparisons have taken into account this financial and technical side of the question, although it is of such great importance, especially in the case of the less wealthy navies. But even the richest ones are limited in their appropriations, and within such limits they have to solve the same problem, though on a larger scale, and for that reason in a more conspicuous manner.

In an article published in this *Rivista*^a I have already had occasion to show that in order to judge of the technical value of a solution we should bear in mind not the total value attained by the results, but the unit value; that is to say, the efficiency due to each ton of displacement. I will not fatigue my readers by repeating the arguments, but must call attention to the fact that the unit ton of displacement does not always cost the same amount of money, and moreover, that the technical efficiency does not always correspond to the political and military efficiency required for different purposes predetermined in the case of each navy.

I shall try to explain my meaning more fully by an example, for before entering upon the merits of the publications before me, which are ready to be placed in the magic lantern to pass before the eyes of the public, it seems to me expedient to fully understand the differences—whether hidden or apparent, artificial or unconscious—which exist in the different tables I intend to discuss.

^aNuovo tipo di nave da battaglia (new type of battleship), December, 1899.

Constructor Gillmor, of the United States Navy, has compiled a comparison^a of the six most successful designs of the six most powerful navies, and has done this in a novel and ingenious manner, which gives evidence of that practical sense which may be characterized by the phrase, "He has known how to make many read him and all understand him."

In the details of the article, which I shall hereinafter sum up as briefly as possible, he has conformed to the idea of units and not to that of totals; and from the quotients obtained by dividing the points of value of each ship by the respective displacement, he has arrived at an order of merit in which the first place is assigned to the *Vittorio Emanuele*.

What are we to infer from this? Is it the intention to demonstrate by this comparison that the other navies have failed or that they have solved the problem less successfully? Are we to infer from this result that if the *Vittorio* were to meet an enemy like the *Virginia* (though a ship which has been so courteous to us in the strife described by Mr. Gillmor, and for that reason has obtained only 47 points of merit to the 52 of the *Vittorio* could never be our enemy) she would be able to defeat her?

The essential point in the comparisons is this: A politician, for instance, may prefer the last type in the list to the first one, because the former is better adapted to his country's colonial aims. A financier might ask that opposite each point of merit be shown the sum with which the budget is to be charged on its account, knowing that the available means are by no means unlimited. An admiral, rather than consider the total displacement and cost of the ships, would look out for the formation of homogeneous groups, for the utilization of the matériel on hand, and for the empty places which must be filled in order to engage in such actions of offense as he may consider most promising against a determined foe. A naval constructor will perhaps approve fully only that design which takes into account all the technical factors that concur to create the total efficiency and consider the relative value of all these factors, leaving out of the question political aims, the cost of fleets, and the plan of attack which varies with each commander in chief.

The *Vittorio* alone against the *Virginia* alone would make good the five points of superior merit assigned to her, perhaps even more. Five *Vittorios* against five *Virginias* would perhaps not succeed in defeating their enemies, and the points of merit would disappear.

I have chosen the *Virginia* (United States), and not the "half-

^aScientific American, Supplement, November 30, 1901; Nautical Gazette, November 28, 1901.

breed" *Duncan* (British), nor the much admired *Mikasa* (Japanese), nor the well-protected *Borodino* (Russian), nor, finally, the weaker *Wittelsbach* (German), all of which are included in the comparison, for the very simple reason that these ships, with the exception of the *Virginia*, are armed only with numerous 6-inch guns, which can not perforate the *Vittorio Emanuele* anywhere, since even her upper-belt armor is 7.9 inches thick, so that in battle (except with torpedoes) all the services to be performed on board will be so protected that it may be said that not even the head of a sailor need show itself outside of that 8-inch face-hardened steel. The large slow-firing guns at the bow and stern, with their limited supply of ammunition, do not, in my opinion, determine the character of the battle during the first and most important part of the action. I remember, with deference and veneration, the forcible saying which our much revered Benedetto Brin used frequently: "Remember that the heavy guns are intended for going close up to the enemy and giving him a final thunderbolt to send him to the bottom."

POLITICAL AND ECONOMIC CRITERIONS.

This example with which I wished to preface the setting forth of the different systems of comparison of foreign ships shows the complex, many-sided and artificial aspect of the question.

To merge together, with equilibrated coefficients of importance, so many different factors is well nigh impossible.

Perhaps it would be more rational, instead of comparing single types, to compare them as a whole in their relation to the fleet. We could then assume for each navy, instead of a single design, several different ones chosen in such manner as to represent on a small scale the characteristic features of the navy to be considered, the same as a differential contains the embryos of an integral. Then, setting opposite each type, besides the point of value, also the point of cost per ton of displacement, multiplying both of these figures by the number of units of each type owned by said navy, and finally getting the two grand totals of the points of merit and of cost, we should have a more logical idea of the technical value of each navy and of its financial value. The types would disappear with their individual characteristics, which have different values when taken separately and not in conjunction with the characteristics of the others, and we should have an integration which at first sight might not appear homogeneous, but which could be improved upon by excluding the smaller types and considering only the first-class armor-clads of each navy. By dividing the total of the points of merit by the number of ships we should have the mean merit of a given organization, and by dividing the total of the cost by the number of ships under consideration we should have the average cost per ton. Finally, by dividing again this cost per ton

by the merit per ton we should know from the quotient how much each point of military merit embodied in a ton of displacement of the whole fleet has cost the country. We should thus have before our eyes only three figures, which might form a foundation for discussions and valuations, without the danger of being carried away by personal sympathies toward favoring one or the other particular design.

The first two figures would represent, respectively, the merit of the whole naval power from a military standpoint and the economic efficiency attained by each design, and finally the quotient would tell us which nation has used to the best advantage the funds which the country has voted for it. If opposite these figures we place the sum of the general budget of the nation, the financier could gain a relative idea of the importance assigned to the navy in the administration of each nation. The extent of the foreign or colonial policy might be considered by the statesman according to weight and merit from these partial figures relating to cruisers or battleships only. Finally, by inquiring into the designs and the number of ships built of each design, the naval constructor could deduce the technical reasons to which the figure representing the military value of each battle fleet must be ascribed.

The systems for making comparisons are legions. It is not with the intention of suggesting additional ones that I have indicated these summary ideas, which should not be lost sight of in the valuation of the total efficiency of designs of ships. My intention was merely to show more clearly the defects of some of the comparisons which I am about to set forth, and which, by assigning excessive value to some factors to the detriment of others, are in danger of reaching inaccurate, illusive, and artificial conclusions.

COMPARISONS BY INSTINCT.

The *Engineer* of October 18, 1901, for instance, has published a comparison of some battleships which deserves attention on account of the final conclusions to which we should be led, if we were to adopt this system for establishing an order of merit.

The anonymous writer of this article deems it unnecessary to take into consideration the armor protection, speed, and radius of action of the different ships and cares nothing for the displacement. Of the armor protection he says that "without any straining of probabilities we may therefore put the knock-out blow from penetration of a belt in the same category as a machinery breakdown; that is to say, count it as a negligible factor in determining a general value."

But that is not all. Not even the energy of fire of the guns is, in the eyes of the author, an efficient factor in the determination of the offensive power, and he substitutes a new method which may be called arithmetical, because it is based on the elementary rule that $2 + 2 = 4$.

He says that two 6-inch guns are equivalent to one 12-inch gun, and for fear that some people may differ with him he adds: "This, of course, is accepted all over the world as an approximate truth." Those who have wasted many years at universities in order to acquire a knowledge of the higher mathematics may well feel sorry that they did not stop at the four elementary operations, for with a little approximation they would be more than sufficient for these computations of the author. They remind me of a man who once suggested to me a very simple method for designing the engine of a new lake gunboat, which was to develop one and one-half times the horsepower of the old one; this was to make the cylinders one and one-half times the diameter of those of the *Guglielmo Pepe*!

Having cleared the ground of this trifling question the author proceeds posthaste to exclude speed. "Speed and handiness," he says, "for equal data are usually about equal * * * the ship that is better armed and armored has, in 90 per cent of cases, superiority in speed and handiness."

If we put together this 90 per cent approximation and that of the above-mentioned rule of arithmetic we shall reach the author's conclusion, which excludes the displacement. "Of displacement we have taken no count, the reason being that to possess a superiority of guns and armor, together with the increased speed, handiness, etc., for which all naval architects aim, increased displacement is an implied necessity, and chiefly a strategical quality."

We might go on gleaning among these blossoms of results in the system of valuation "by instinct," but I prefer to reap at once, and not keep the reader longer in suspense. The victor in the competition is, of course, the *New Jersey*, because she is the largest of all, and hence has more guns than all the others.

COMPARISONS ACCORDING TO ENERGY OF FIRE.

Let us pass on to another system. We have had occasion before (see *Revista Marittima*, December 1899, p. 444) to mention a classification by Lord Brassey, a recognized authority in naval matters (see *Brassey's Annual*, 1899, p. 178), compiled according to the energy of fire developed in a given unit of time by the guns of all the modern first and second class ships, hence on the basis of a single one of the factors excluded in the system referred to in the preceding chapter. In Brassey's comparisons the *Regina Margherita* came out second among the first and the *Ferruccio* first among the second class ships. These ships represented at that time (1898) the best types of the Italian navy.

A friend of mine, who is fond of joking, said to me that in olden times Cæsar might have preferred being first in a small town in the Appenines to being second in the city of Rome, but that nowadays apho-

risms are misfires when it comes to the question of guns, because the twelve 6-inch guns of the *Ferruccio*, placed all in one line, with their total energy of 324,520 kilometer-kilograms (1,044,954 foot-tons), would never succeed, under battle conditions, in piercing a 6-inch Krupp armor in the given period of 5 minutes, for the simple reason that the ogival heads of the numerous projectiles fired in the five minutes are not in the habit of all entering the same hole. And this friend added that if the ogival heads were drill-points they might finally succeed in making the hole which an 8-inch shell would make at one blow, with an energy of only 49,110 kilometer-kilograms (158,134 foot-tons).

But I had cited my authority, and so could not be accused of partiality in showing up the merits of Italian ships as compared with foreign ones, when such merits had been recognized by a foreigner who, moreover, is a very competent man.

I have since tried to improve on the accuracy of the comparisons by introducing, as will appear later, another factor, neglected by Lord Brassey, namely the maximum perforation attainable by the largest-caliber gun of each ship. This new factor is certainly of importance, because in the comparison it keeps a vessel having one hundred 4-inch guns from defeating a battleship having four 12-inch guns, outside of the secondary battery. Through the introduction of this additional point of merit for the maximum perforation attainable by the largest-caliber gun, a slight superiority is assigned to the ships capable of firing that thunderbolt intended to send the enemy to the bottom in the second and final part of an action. Ships of the *Bogatyr*, *Garibaldi*, *Asama*, and *Filiberto* types, and all the German and Austrian ships armed only with 9.4-inch guns, suffer somewhat in the comparison, but on the other hand the imputation previously mentioned relative to drill-point heads of shell no longer endangers the conclusions reached.

COMPARISONS WITH IMAGINARY DESIGNS.

In a lecture held before the Congress of Naval Architecture and Construction at Paris (Les trois fusions futures, by V. E. Cuniberti, July, 1900) I had an opportunity of testing such a system in comparing 36 ships of different designs. By choosing for each navy several of the most prominent designs one may gain a better idea of the different navies than by selecting one, for the reasons above set forth. But there is the drawback of comparing displacements and types which differ from each other, to the obvious detriment of the smaller types.

To avoid such errors, partly at least, I have considered only the unit efficiency—that is, the efficiency per ton of displacement—which I have previously mentioned, and in order to render it possible to add the different efficiencies I have reduced them to decimals in the following manner:

As a type ship an imaginary ship was assumed embodying all the best features of the 36 ships compared—that is, being equipped with the most powerful guns of those 36 ships, protected after the manner of the best armored ship, having a speed equal to the fastest one, and a radius of action equal to that of the ship “having the longest legs and most ample lungs” of all. But the special ideal merit of this unattainable ship was that it inclosed all these properties in a moderate displacement, the influence of which was constantly introduced into the computation by substituting for the absolute values of the points of merit their relative values per ton of displacement as compared with this type ship. For instance, if we examine the table in which the principal results of this comparison are summed up, we shall see that for the maximum protection per ton the *Karl VI* of the Austrian navy has the largest number of points of merit, because the designer of that ship has known how to give a thickness of 8.7 inches to the armor of a ship which, besides being well armed and of considerable speed, displaces only 6,240 tons of water. Hence, to each 1,000 tons displacement she has 1.37 inches armor, while the *Garibaldi*, although likewise well protected as compared with her moderate displacement, has only 0.79 inch; the Russian *Bayan*, of almost the same displacement, 1.02 inches; the French *Charlemagne*, which is much larger, 1.06 inches; and the United States *Maine*, of 12,500 tons, 0.95 inch. In order to reduce these efficiencies per ton to decimals, the maximum value 1 has been assigned to the *Karl VI*; consequently the corresponding value of the *Garibaldi* was 0.58; that of the *Bayan*, 0.75; that of the *Charlemagne*, 0.77, and that of the *Maine*, 0.69.

The same for speed. To each 1,000 tons of displacement the *Karl VI* has the speed of only 3.2 knots, while the *Bogatyr*, whose speed is 23 knots, obtains the highest figure of merit, namely, 3.8 knots to each 1,000 tons of displacement, or 0.0038 per ton of displacement. To her, therefore, was assigned the decimal efficiency 1 for speed, while that of the *Karl VI* is only 0.78.

It will at once be understood from these brief explanations that the ship which has the maximum efficiency in each case—that is to say, 1 for each of the five characteristics under consideration, namely, armament, perforation, protection, speed, and radius of action—will attain the largest total of these efficiencies, namely, 5.

But this value of 5 can be assigned only to the imaginary type ship which I have assumed for comparison, while the actual ships will approach this value more or less according as the partial decimal efficiencies will be more or less high and capable of raising the total efficiency.

COMPARISONS OF DIFFERENT FLEETS.

This system, as stated at the outset, has the defect of comparing ships of different displacements and types; but taken as a whole the

ships of a power give a better idea of its navy than when each navy is represented by a single ship which can not embody the merits of all the others.

France, which in the *Desaix* with a 4-inch armor belt obtains a total figure of merit of 1.96, and in the *Guichen*, less well protected, of only 1.38, has, on the other hand, in the *Henri IV*, 2.58, because the latter ship, though of limited speed, is very well designed as to her armament, especially her 11-inch armor, with the very moderate displacement of less than 9,000 tons. The *Montcalm*, protected only with 6-inch armor and less well armed, goes down to 2.01 of total war efficiency, followed closely by the *Condé* with 1.94 and the *Jeanne d'Arc* with 1.74. But even the *Jéna*, *Charlemagne*, and *Suffren* types compare well with each other if it is not desired to compare them with the above-named cruisers; their respective points of merit are 2.64, 2.97, and 2.70, for while the *Suffren* has two more 6.5-inch guns than the *Jéna*, her armor is inferior to that of the *Charlemagne*, which displaces 1,500 tons less.

The same considerations apply to England. The table of comparisons comprises only 10 English designs, representing about 60 ships, but they are sufficient to give an idea of that powerful navy, which, as stated before, can not be represented by the *Duncan* alone. In fact, in the classification this ship has the figure 2.06, which is naturally more than that of the less well protected and armed *Drake*, namely, 1.35, and of the *Powerful*, with still less armor, but almost the same armament, which is only 1.19. To judge of the new conceptions which were carried into effect after the construction of the *Powerful* it suffices to compare the *Diadem* with the *Kent*, of which latter type a number of ships have been built. Both lack heavy guns, and they have respectively ten and fourteen 6-inch guns, but the latter with a less displacement has been able to attain a speed of 2 or 3 knots more than the former, in spite of her 4-inch armor at the water line, the use of which, to tell the truth, I do not quite understand.

How has this double improvement been brought about? At the expense of what? The 22,000 horsepower must surely weigh more than the 17,000 of the *Diadem*, and where has the weight of the armor been cut down? It is a fact, nevertheless, that the *Kent* class is much superior to the *Diadem* type, the former having a value of 1.51, as against 1 of the latter.

But passing from the cruisers to the battleships we see that from the *Renown* to the *Canopus* there has been an improvement in the heavy armament, and therefore the figure of merit has risen from 1.54 to 2.18, while the value of the old *Majestic*, which is 1.92, has risen to only 1.97 in the improved and faster *Formidable* type.

From this brief examination it will be understood why the *Duncan* has been selected as the best representative of English designs, for she

appears in this table with a value of 2.06, which is superior to that of all the other English types.—[TRANSLATOR'S NOTE.—The *Canopus* appears in this table with a value of 2.18.]

Italy, finally, is represented by six types, which are the latest ones designed for our Navy.

The *Re Umberto*, *Sardegna*, and *Sicilia*, which occupied the first place in the comparison of 1893, of which I shall speak later, reach at present a value of only 1.47, while the *Filiberto* goes up to 2.30 and the *Regina Margherita* to 2.53, especially because these ships have good secondary batteries, and for that reason the maximum rapidity of loading has been taken into account in the determination of the total energy of fire. But it should be remembered that this rapidity will be considerably reduced when, instead of rapid practice firing, ordinary firing is done in battle where accurate aiming is required. In that case the figure of merit for the *Re Umberto* would become 1.42; for the *Filiberto*, 2.17; for the *Regina Margherita*, 2.50; and for the new *Garibaldi*, *Ferruccio*, etc., 2.99.

If we add to the original table the *Vittorio Emanuele*, she would carry off a figure of merit of 3.30, which is superior to that of any of the types included.

The table compiled in 1900 includes also the battleship design of about 8,000 tons, of which four were to be built by private industry under Bettòlo's administration. This ship has given origin to the *Vittorio Emanuele*, but for one of the six turrets for twelve 8-inch guns a more powerful armament has been substituted, which is capable of perforating 12 inches and even thicker belts, and the displacement has been raised a few hundred tons beyond the 8,000.

The efficiency of this ship would be about 4.32 in the table, surpassing all others, and would perhaps reach a still higher figure if the displacements were increased, even though the maximum speed of 23 knots could not quite be reached. But to attain these results we must conform to the special shapes of hulls set forth in this *Rivista* (*Rivista Marittima*, January, 1901, page 41: Programmi navali o tipi di navi) and analogous shapes as designed by my colleague Soliani for a displacement only a little larger. And it is quite possible, in view of the discussions which have taken place on this subject abroad, the publications in *Schiffbau* and the *Marine-Rundschau*, and the lecture of Constructor Sabath, that this type has served as the basis for different studies made in one of the principal northern navies, and that it has at the same time induced a secondary navy, further remote from us, to turn its eyes to that type, and to the modifications of which it may admit, and we look forward to seeing it carried into effect so as to demonstrate still further the correctness of our design, although it has been attacked by some constructors in Italy, who affirm that it is impossible with about 8,500 tons displacement to carry into action, at the high

rate of speed of 22 or 23 knots, an armament of ten or twelve 8-inch guns, well protected in turrets, besides the 6-inch guns inclosed in the battery, with a limited field of fire.

COEFFICIENTS OF IMPORTANCE OF THE CHARACTERISTICS.

One of the most justifiable objections that might be raised to these comparisons is that to none of the characteristics—energy of fire, perforation, protection, speed, and radius of action—coefficients of importance are assigned according to which their influence upon the total efficiency could be graded.

What we have done is to reduce to decimal fractions each absolute value, or value per ton of displacement, and then to add all these partial values, giving, erroneously perhaps, in all the types the same weight to the radius of action as to the armament, the same to the speed as to the protection, etc.

Now, if there were no divergence among the different types there would be no merit in giving them numerical values for the sake of comparison. Hence the whole skill consists in “not too openly carrying water to our own mill” by assigning excessive values to some characteristics which are in our favor and by underestimating others which we do not possess. And here lies the danger which may arise from the use of coefficients of importance, which are a matter of personal opinion and should therefore not find a place in a fair judgment. On the other hand it would not be rational, in order to avoid that danger, to confront the other one of putting all the characteristics on the same footing, were we not comforted by the thought that the political aims of a given navy are different from those of other navies, and this fact renders it necessary to give to those nations which are rich in steamers and colonies a high coefficient for the steaming radius of their types, while for other countries, whose sphere of action is more restricted, the same coefficient would no longer be proper. The same applies to speed, which is needed more by some nations than by others, while armament and protection are to a greater degree common requirements of all. For these reasons we have chosen the lesser of two evils—that of using equal values for all.

The assignment of coefficients of importance to the different factors constituting the efficiency of a ship's type is not only a difficult matter, and, as stated above, incompatible with the different aims of the different powers, but it is also work of transitory worth, because the value of a weapon, the efficacy of a type of armor, the efficiency of a given velocity, may be affected disproportionately in the course of a few years by some essential change in the arrangement of the interior protection, the manufacture of the outer armor, the use of explosives, etc.

Without going back to the systems used by Marshall and Barnaby

in the determination of the value of a ship and comparison of the same with others, we will cite, in support of the difficulty above referred to, the complicated, but ingenious system which appeared in the report on the naval budget for 1893-94 for comparing the Italian navy of that time with the French. Anyone who will undertake to plunge into a study of this system and its conclusions will find that the views of the reporter of that budget were both wide and deep.

We will confine ourselves to showing how great the influence of the few years which have elapsed since then has been on the values assigned to the coefficients of the four factors considered in said report; namely, armament, torpedo tubes, armor, and speed. Of the radius of action, a strategic rather than tactical attribute, the author, the Honorable Bettòlo, has taken no account in the determination of his coefficient of the military efficiency of battleships, and the formula which sums up and determines such efficiency is as follows:

$$K \times \frac{\text{Displ.}}{15,000} \left(\frac{d}{M} + \frac{\sqrt{N}}{6} + \frac{S [10^2 + (s-10)]}{580} + \frac{V}{20} \right)$$

wherein K represents the coefficient of age; d , the energy of fire in kilometer-kilograms; M, a million kilometer-kilograms assigned to the type ship of 15,000 tons displacement; N, the number of torpedo tubes; S, the ratio between the protected area and the total area; s , the maximum thickness of the armor in centimeters; V, the speed of the ship in knots.

The coefficient of age, which is assumed to be 1 for modern ships (1886 to 1893) sinks gradually to 0.5 for ships built prior to 1865, and the value $(s-10)$ represents the thickness of the armor after deducting therefrom the 10 centimeters preceding, which are raised to the square.

Upon an examination of this formula it will at once be noticed that by putting the displacement in the numerator too much weight is allotted the ships approximating 15,000 tons, while the power is reduced one-half, other conditions being equal, where the displacement approximates 7,500 tons. And by comparing the Italian ships *Lepanto*, *Sicilia*, *Sardegna*, and *Re Umberto*, which have large displacements, with the generally smaller French ships there is evidently on the above assumption a considerable advantage in favor of the large ships. The first place in the order of merit of Italian and French ships being occupied by the *Sardegna*, with a figure of merit of 0.493, which is far superior to that of any of the French ships of about 10,000 tons, and even superior to that of the *Charles Martel* and of the *Bouvet*, whose respective values are 0.427 and 0.435, although the speed of the former is one knot more than that of the latter, but the secondary armament of the former is slightly inferior. But since the *Charles Martel* has 400 tons less displacement, it is obvious that she could increase the number of her small guns as much as desired and still retain a superiority in speed over the *Bouvet*.

Nowadays the lesser displacement is considered a point of merit instead of amounting to a reduction of efficiency, as would be the result if we were still to apply that formula.

If we now proceed to examine the comparisons of the armor, we shall perceive that the budget reporter has assigned great importance to the 10-centimeter (4-inch) armor of the *Sardegna*, because "besides possessing the faculty of arresting the projectiles of small-caliber guns, it also answers the purpose of attenuating the effect of large projectiles with high explosive charges; because it prevents them from exploding in the interior of the ship and causes them to burst at the first impact. Moreover, in view of the fact that heavy armor plate has a proportionate resistance greater than the thickness, but less than the square of such thickness, the formula contains the first 10 centimeters raised to the square and the remaining thickness in the first power only." Therefore, in the numerator the area of the armor (or rather the ratio between the protected part and the total lateral area of the ship) is multiplied not by the thickness of the armor plate, which is 10 in the *Sardegna* and 45 in the *Charles Martel* and *Bouvet* types, but by 10^2 , or 100, in the case of said Italian ships, and by $10^2 + 35$ in the case of the *Bouvet*. The denominator is computed for the type ship, with complete armor, 4 meters (13.12 feet) wide and 55 centimeters (21.65 inches) thick, as follows:

$$\frac{L}{L} \times 4 (10^2 + 55 - 10) = 580.$$

Aside from the consideration that even prior to 1893 to assign 100 points to the armor of the *Sardegna* and only one-third more, or 35 points, to an armor four and one-half times as thick, like that of the French ships, would seem to attribute too high a value to the functions causing the detonation of shell, it is obvious that at present, in any event, this valuation would be inaccurate, the same as that relating to the influence of the displacement, previously referred to; because, with the improved processes of armor manufacture and the substitution of semi-armor-piercing shell for high-explosive shell with thin walls, the protection of ships of the *Sardegna* type has become wholly inefficient.

Without going into details as to the other factors, namely, the rational decrease of the energy of fire with the decrease of the caliber of guns, in order to determine the maximum perforation of the heavy guns, the reduction to the square root of the number of torpedo tubes (six have been assumed for the type ship), in order to determine the total quantity of gun cotton and its destructive effects, and finally, without pointing out the influence of the use of the first power in the value of the speed of the ship under consideration as compared with the 20-knot type ship, we may conclude that the formula could hardly be applied nowadays without arriving at conclusions which would

little conform to modern ideas as to the total efficiency of a battleship.

Perhaps, when properly modified, the formula might still represent the present situation of the coefficients referred to in their relation to each other and with regard to the imaginary ship taken as a pattern, having the maximum requirements within a minimum displacement. But we should remember that nowadays it is better, for the purpose of comparison, to assume an imaginary but at the same time practicable ship, which, having the minimum rather than the maximum factors, might be called the least common divisor of all the units to be compared.

COMPARISON WITH AN IMAGINARY BUT PRACTICABLE SHIP.

To obviate the use of different coefficients of importance for the various characteristics of the ships under consideration, or at least to substitute a practical rule for the hypothetical orders of merit which are sometimes used as a foundation in the compilation of comparisons, Naval Constructor Gillmor, of the United States Navy, has substituted a practicable ship for the imaginary type assumed by me in the table of comparison of 36 designs of ships, a type absolutely unattainable, because it is impossible, as above stated, to embody in a minimum displacement all the maxima of armament, protection, speed, and coal capacity of the different ships compared. This practicable ship, which fulfills the functions of the touchstone in this experiment, is larger than all others and can therefore easily carry the least guns of all, the least protection, and have the least speed and smallest coal supply of all the ships considered. In this practical feature lies the ingenuity of the new system, which was the subject of a lecture delivered November 14, 1901, before the ninth annual meeting of the Society of Naval Architects and Marine Engineers at New York.

Mr. Gillmor begins his lecture by saying that it would be interesting to classify the modern foreign battleships, and that it is possible and practicable to do so, because there is no other class of work that has been subjected to so much international discussion and study as the designing of new war ships.

As ships are built to cope with foreign ships it is necessary to study the characteristics of such foreign ships in order to fashion accordingly the engines of warfare which are intended to cope with them. According to the author, seven such ships should be studied, because there are seven great navies; but as sufficient data concerning the latest French design is not available, he had to confine himself to six, namely, those of the United States, Russia, Japan, Germany, England, and Italy.

As to his choice for his own country [the *Virginia*], he could certainly not have made a better one. * * *

For the Russian navy he has chosen the *Borodino*, which is a good selection. If this ship is not assigned a higher place in the classification, it is due to the fact that her excellent protection, which in many

respects is more rational and efficient than that of all the other ships, has not been fairly computed.

The *Mikasa*, chosen as the representative of the Japanese navy, is the best that private industry in England has traced in the steps of the Admiralty. This industry has always done great honor to the work of perfecting details, and if it has not always carried off the first prize for new and original ideas, it is principally due to the conservative spirit which has caused it to reproduce the design of the *Majestic*, although antiquated. By mistake, Mr. Gillmor assigns to this ship four 10-inch instead of four 12-inch guns.

Germany has made great strides since the *Wittelsbach* was designed, and therefore the choice of this ship, which occupies only the fourth place in the order of merit (after my corrections she takes the third place), does not seem just. It is true that she has the smallest displacement with a speed of 19 knots; but the new types of 13,000 tons displacement would probably have made a better showing in the comparison, since they are more powerfully armed and equally well protected. The normal coal supply of these ships, however, limits their steaming radius too much.

* * * * *

Why did Mr. Gillmor not choose the new English ships of almost 17,000 tons instead of the *Duncan* of 14,000? Are not the latest ships better representatives of the power of the British navy? The armor of the *Duncan* is so tapering, both in thickness and width, especially toward the stern, as to render it doubtful whether she can really be classed as a line-of-battle ship.

But if we divide the points of merit of the *King Edward* by 17,000 tons we shall have a figure of merit less than that of the *Duncan*, because the greater value of the armament does not compensate for the 3,000 tons which go toward increasing the divisor. On the other hand, we have already stated that in the comparison of the 36 designs of ships the *Duncan* has a figure of merit superior to all the other English ships.

For the Italian navy the *Vittorio Emanuele* has been chosen. In giving the characteristics of the *Vittorio* some inaccuracies have slipped in, which, however, can not materially alter the final order of merit, in which this ship occupies the first place with 52 points of merit, leaving the *Virginia*, with 47.2, about 5 points behind.

As to these inaccuracies, we will first point out that it is obvious, for instance, that the idea of a powerful 8-inch battery was founded on the advantage of perforating the 6-inch armor plates which are at present so extensively used on foreign ships. But as the construction of Italian ships, owing to the scarcity of available funds, always requires many years, a more extensive use of the 8-inch gun on board of foreign ships was to be foreseen, and, indeed, it has become an accomplished

fact in the United States and British navies, and the probability is that France and Germany will follow. It therefore seemed evident that an upper belt of only 6 inches thickness would be incompatible with the 8-inch armament, and so, to safeguard our ships in the future against the attacks from 8-inch guns, which the other navies would not fail to use, reasoning just as we have done, an upper belt of 7.9 inches thickness, extending about 7.9 feet above the 9.8-inch water-line belt, was adopted. The latter being 9.8 feet wide, the ship has a positive protection over a width of more than 16 feet from the 8-inch hostile guns of the future.

This upper belt extends to the bow, where it tapers to 1.9 inches, the same as that of the *Borodino*, to guard against rents in the ship's side, which would be even more serious in the case of our ships, because they would reduce the high speed, which is one of the salient features of this type.

But while on this account the figure of merit should be increased, we have to concede, on the other hand, that the value of the superior speed allotted by Mr. Gillmor to our design as compared with the type ship is probably excessive. But the total value of the protection of only 190 points, as against 1,430 for the *Virginia*, 1,350 for the *Mikasa*, and 1,110 for the *Duncan*, seems very strange to me, to say the least. In fact, it is my opinion that errors must have slipped in in the copying of the table, which appeared in the *Scientific American*, Supplement, of November 30, 1901, and in which I have therefore made corrections.

For the upper belt only 80 points are allotted to the *Vittorio Emanuele*, while the *Virginia* and *Mikasa*, whose protection is less, have 120 and 190 points respectively. For the protection of the 12-inch guns the figure of the *Vittorio* is zero, being considered equal to that of the type design, namely, the minimum, although 7.9-inch curved armor is a sufficient protection for a single gun which is not considered an indispensable weapon, but a reserve for the deathblow. Moreover, only the ammunition tubes are assumed to be protected, while, as a matter of fact, there are two strong redoubts under the 12-inch guns. For the protection of the second-caliber (8-inch) guns, which are installed in 6-inch turrets—hence equal to the protection of the turrets of all the other ships, and, for obvious reasons, superior to that of the casemates—the figure of merit should be 160. But a minus sign (—) has been placed in front of the 160 without apparent reason, and these 160 points are deducted from instead of being added to the total number of points, thus making a difference of 320 points less.

* * * * * *

The dimensions of the hull, the protective decks, the small machine guns, the torpedo tubes, and the steaming radius in miles, together with the normal total coal supply, do not have any material influence

upon the final results in this system adopted by the author, although he justly remarks that the *Borodino*, and other designs not well known to the public, lose somewhat in value by neglecting their horizontal protection. The wisely moderate values assigned to the torpedo tubes and small guns do not add even one-quarter of a point to the value of the ships that are best equipped in this respect, since a ship of 14,000 displacement would need at least 140 points to gain one-hundredth of a point of merit. Any ship can, by a small increase in displacement, be equipped with these devices.

While adhering on the whole to Gillmor's statements we shall try to obviate his inaccuracies in the following tables:

VIRGINIA.

	Points or tons.
Four 12-inch guns instead of four 9.4-inch.....	160
Eight 8-inch guns more than type design.....	350
Additional small guns	40
	550
Heavier and more extended water-line belt	410
More extended upper belt.....	120
Greater protection of 12-inch bow and stern turrets.....	620
Greater protection of 8-inch turrets.....	240
Greater protection of 6-inch guns	40
	1,430
Normal coal supply in addition to that of type design.....	250
	2,230
Total additional value	2,230
According to the authority previously cited the displacement will probably be about 16,000 tons, and the speed would be reduced to 18 knots, which is that of the type design, the value of which is.....	4,300
	6,530
Total value of <i>Virginia</i>	6,530
Dividing this figure by the displacement we obtain an efficiency per ton of...	0.410
The author, assuming instead a displacement of 14,950 tons and a speed of 19 knots, allots 520 points for the weight of the additional machinery which would be required by the type design in order to attain a speed of 1 knot more. In that case the value of the <i>Virginia</i> would rise to	7,050
And the efficiency per ton to.....	0.472

DUNCAN.

Four 12-inch guns instead of 9.4-inch	160
Two additional submerged torpedo tubes	30
	190
Heavier and more extended upper belt	350
Greater protection of 12-inch barbette.....	500
Greater protection of 6-inch casemates	260
	1,110
Additional normal coal supply	250
Weight of additional machinery to attain 1 knot more speed than type design.....	450
	2,000
Total additional value	2,000
Value of type design.....	4,300
	6,300
Total value of <i>Duncan</i>	6,300
Efficiency per ton	0.45

BORODINO.

	Points or tons.
Four 12-inch guns instead of 9.4-inch	160
Additional small guns	50
Additional torpedo tubes	30
	— 240
Heavier and more extended water-line belt	100
More extended upper belt	200
Greater protection of 12-inch turrets	450
Protection of portion of secondary battery	120
	— 870
Additional normal coal supply	250
Increase in machinery weights for speed of 18 knots	130
	—
Total additional value	1, 490
Value of type design	4, 300
	—
Total value of <i>Borodino</i>	5, 790
Efficiency per ton	0. 42

MIKASA.

Four 12-inch guns (Gillmor erroneously gives these as 10-inch guns)	160
Two additional 6-inch guns	50
Additional small guns	20
Additional torpedo tubes	20
	— 250
Heavier and more extended water-line belt	350
More extended upper belt	190
Greater protection of 12-inch turrets (<i>Virginia</i> 620 ?)	580
Protection of secondary battery	190
	— 1, 310
Additional normal coal supply (Gillmor assumes 1,400 tons)	50
Increase of machinery weights due to weights added above	230
	—
Total additional value	1, 840
Value of type design	4, 300
	—
Total value of <i>Mikasa</i>	6, 140
Efficiency per ton	0. 40

Comparing the heavy protection of the bow and stern guns of the *Mikasa* with the 10-inch protection of the *Virginia*, it seems to me that the allotment of only 580 points to the *Mikasa* for this advantage over the type design is incompatible with the allotment of 620 points to the *Virginia*. I consider it just, therefore, to give the *Mikasa* 100 points additional, which, with the 110 points I have already added for the 12-inch guns, makes an increase of 210 points, from which should be deducted the coal, for while the bunker capacity of the *Mikasa*, *Hatsuse*, *Asahi*, and *Shikishima* is the same, 1,400 tons, the normal coal supply of these ships is only between 700 and 1,000 tons. Taking the highest figure, 1,000 tons, as normal, 350 points more should be assigned for coal over and above that of the 650 tons of the type design; as 50 tons have been included above, we should have a total of 6, 540

And an efficiency per ton of 0.43 instead of 0.443 assigned by the author.

WITTELSBACH.

	Points or tons.
Six additional 6-inch guns	145
Additional small guns	10
Additional torpedo tubes	25
	— 180
Heavier and more extended water-line belt	130
Greater protection of 9.4-inch guns.....	80
Greater protection of six 6-inch guns	240
	— 450
Increase in machinery weights for weights added above and for 1 knot more speed than type design	330
	—
Total additional value	960
Value of type design.....	4,300
	—
Total value of Wittelsbach.....	5,260
Efficiency per ton.....	0.44

VITTORIO EMANUELE.

Deduction for less efficiency of two 12-inch guns, as against four 9.4-inch guns.....	—50
Twelve 8-inch instead of twelve 6-inch guns.....	220
Additional small guns	20
Additional torpedo tubes	30
	— 220
Heavier and more extended water-line belt (9.8 inch instead of 7 inch) ..	270
Heavier and more extended upper belt (7.9 inch instead of 6 inch).....	350
Armor of 6 turrets for twelve 10-inch guns	300
	— 920
Additional normal coal supply	350
Increase of machinery for 3½ knots additional speed	1,040
	—
Total additional value	2,530
Value of type design.....	4,300
	—
Total value of Vittorio Emanuele.....	6,830
Efficiency per ton	0.54

Among the changes which I have been able to make in Gillmor's computation with regard to the *Vittorio Emanuele*, the most important one is the deduction of nearly 500 points which I deemed it my duty to make from the 1,500 which the author has allotted to this ship for speed.

Without entering into the merits of the important question of the greater or less value of high speed, especially when *possessed in common by five ships that are entirely homogeneous as to armament and protection*, we will only say that if high speed is wanted it must be paid for, whether it is worth it or not. The main difficulty lies in estimating correctly the displacement for weight of the machinery which would have to be increased in the case of said type ship, in order to enable

her to carry not only all the additional armor, armament, and coal already computed, maintaining her speed of 18 knots, but also the additional weights necessary to raise such speed to that of the *Vittorio Emanuele*.

It is in this connection that arises the most serious criticism, which, from a technical standpoint, might be raised against Mr. Gillmor's ingenious system.

As previously stated, the value of the technical efficiency per ton of displacement is different from that of the total military efficiency of a ship.

These points of merit would be all right if those who designed the *Virginia* had sat with us on the benches of the school of naval construction, together with Sir William White, Mr. Watts, Mr. Bertin, or even those two captains of the German navy, the one who was afraid of the metacenter and the other who, we trust, will not be afraid of it in designing new ships. But where the financial question does not come into play, the unit efficiency—that is to say, the efficiency which each constructor has known how to derive from each ton of his displacement, thanks to the ingenuity of his expedients—can not enter into the account. If the financial question, which is of such high importance, whether the budget is small or large, is eliminated, we can compare only the total military power of the individual ships or of homogeneous divisions adapted to carry out the respective aims of each navy.

Hence the large ships represent the maximum power only when the financial question is eliminated, and this applies still more to the tactical and strategic power of a large number of ships against a small number.

I have to add another criticism against the system adopted by Gillmor which is founded on taking as a type design the *largest ship* having the *smallest armament, protection, and speed* of all the different types compared. In principle, all goes well; the guns are increased, the armor is made thicker, and 500 tons of coal are added to the 650 supposed to be already on board the type ship. But this ship, already assumed to be larger than all the others under consideration, will thereby become excessively large and the weight of the machinery must also be increased in order to preserve the speed of 18 knots. But who could conceive the idea of such a ship receiving sufficient machinery to make 21 or 22 knots? And even if this were practicable, what resemblance would that gigantic type ship and the rating of 0.52 point bear to the real value of the *Vittorio Emanuele*?

Unless I have not sufficiently grasped the innermost essence of this system I might compare it with that of an artist having in his studio six wooden manikins of herculean proportions, but scantily clothed, and trying to dress them with the weapons, gauntlets, and coats of

mail of six live warriors of different heights. As long as it were a question of putting a sword on one and a dagger on another, all would go well; but when the artist should try to put the different sized coats of mail, helmets, gauntlets, etc., on the six giants, some might fare well, but the others could not be dressed. But even supposing that with much good will and *skillful compensations*, with patches and strings and straps the artist succeeds in putting all the clothes on the six manikins, what a strange appearance these six different types would present.

I do not know whether Gillmor intends to proceed in the same manner, but if so I must say that while the *Mikasa*, the *Virginia*, and perhaps the *Duncan* would not be disfigured, I should much prefer the *Vittorio Emanuele* of 12,624 tons to the phantom ship that would be the result if the giant's lungs—that is, the boilers and engines—were enlarged in order to maintain the desired speed, thanks to the 1,500 tons which the author assigns to her.

The speed of 22 knots (and not 23, as erroneously stated by some who have confounded this type with that of 8,000 tons), which the model at the experimental tank made us hope that the ship would attain at the trials, provided the efficiency of the screws, engines, etc., is as high as shown in the official reports of some of our ships, is certainly a high rate of speed for a first-class ship, but it can be attained with the characteristics of the 8,000 or 9,000 ton design, which, with proper modifications, have in part been preserved when the displacement was raised to 12,624.

If these conceptions were extended to the 15,000 tons of the *Virginia* or the 17,000 tons of the *King Edward* (the 2,000 or 3,000 points of the *Vittorio* would carry the 15,000-ton type ship even beyond these enormous displacements), we should face another problem, the solution of which would no longer have anything in common with the *Vittorio Emanuele*, but would come under the views of another navy, as was hinted by the *Engineer* at the conclusion of its article in the issue of June 7, 1901, page 585, on the subject of our designs of ships.

I was therefore of the opinion that we ought not to keep the 1,500 points assigned to us by Gillmor for additional machinery of the large manikin—that is to say, the type ship—in order to enable the latter to make 22 knots.

Even if the results are not as good as anticipated, the *Vittorio Emanuele* will be sure to have a speed of 21.5 knots, but the points accredited to us are only relative to the 520 points assigned to the *Virginia* for 1 knot additional speed, and I have estimated the merit for only 2 knots more than the type design (1,040 points in place of the 1,500 allotted to us by Gillmor).

On the other hand, it seems to me that the four turrets of the eight 8-inch guns of the *Virginia* are overestimated at 240 points, while to

our eight 8-inch turrets are allotted only 160 points, which, moreover, as stated above, appear in the total as a negative value. I have therefore carried the value of the six turrets to 300 points, as against 240 for the four of the *Virginia*.

Thus, also, the small-caliber guns of the *Virginia* are not superior to those of the *Vittorio*, and yet the former have been given 40 points and the latter only 20.

Finally, as Gillmor has probably taken the data of the *Vittorio* from the *Engineer* of March 15, 1901, page 260, where the thickness of the upper belt is erroneously stated to be 6-inch instead of 8-inch, we have only 80 points for "more extended upper belt." But as the *Duncan* was given 300 points, although her upper belt armor is only 7 inches thick as against our 7.9, I have confined myself to estimating it only equal to that of the *Duncan*. No allowance is made in Gillmor's table for the upper belt of the *Vittorio* extending to the very bow, as in the case of the *Duncan* and *Borodino*.

The new *République* and *Patrie* type of the French navy was not included by the author for lack of data.

I have deemed best to include it in the tables, taking the data from recent technical publications. The following table shows the best possible efficiency of this type according to Gillmor's system:

PATRIE.		Points or tons.
Four 12-inch guns	160	
Additional 6.5-inch guns and their superior energy	200	
Additional small guns	50	
Additional torpedo tubes	30	
	440	
Heavier and more extended water-line belt	410	
Inferior upper belt (2.5 inches)	—100	
Increase for protection of medium-caliber guns	300	
	610	
Additional normal coal supply	250	
Machinery weights to maintain speed of 18 knots	230	
Total additional value	1,530	
Value of type design	4,300	
Total value of <i>Patrie</i>	5,830	
Efficiency per ton	0.40	

Summing up the partial and total values we have:

	Vittorio E.	Duncan.	Wittels- bach.	Boro- dino.	Virginia.	Patrie.	Mikasa.
Additional offensive value	220	190	180	240	550	440	250
Additional defensive value ...	920	1,110	450	870	1,430	610	1,310
Additional value for machin- ery and coal	1,390	700	330	380	250	480	280
Total additional	2,530	2,000	960	1,490	2,230	1,530	1,840
Efficiency per ton	0.54	0.45	0.41	0.42	0.41	0.40	0.40

COMPARISONS OF ARMAMENTS.

Chief Engineer of Ordnance Sabath, Austrian navy, discussed in his lecture, previously referred to, chiefly that part of the problem of naval architecture which concerns itself with the caliber and arrangement of guns and their efficiency on board of war ships. In reading this lecture (see *Mittheilungen aus dem Gebiete des Seewesens*, June, 1901, p. 459), and noticing the conciseness and clearness of his ideas, I was wishing that gradually there might be organized among the engineers of the Italian navy also a class that would familiarize itself with the study of naval ordnance and use such knowledge subsequently toward solving the complex problem of war ships, of which the armament forms a part that is becoming more important every day, and is intimately connected with the ship's hull.

In speaking of the armament of the twelve 8-inch guns introduced by us, the lecturer can not but concede their importance and commend the innovation. In comparing this armament with the 9.4-inch and 12-inch armaments he draws very apt conclusions as to the weight of the respective weapons, their mounts, ammunition, and protection, and as to the perforation which can be achieved with these different calibers in battle at various ranges.

It is true that our 8-inch gun is a little heavier than the Krupp gun considered by the author, but the principal advantages which it embodies over the different armaments of modern battleships deserve to be pointed out in the following table, in which the author compares the said 8-inch gun, the 9.4-inch gun used as the largest caliber on board the *Wittelsbach* class, the 11-inch gun to be installed in the bow and stern of the new 13,000 ton battleships of the German navy, and the 12-inch gun to be found in the bow and stern of the *Vittorio Emanuele*, and of the principal modern ships of foreign powers:

Gun.		Velocity in feet at ranges of—					Velocity necessary to perforate.		
Caliber.	Weight.	0 yds.	1,094 yds.	2,187 yds.	3,281 yds.	4,374 yds.	11.8"	9.8"	6"
	<i>Pounds.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>	<i>Feet.</i>
8-inch ..	33,951	2,690	2,464	2,250	2,050	1,863	2,591	2,250	1,624
9.4-inch	56,218	2,690	2,500	2,322	2,149	1,988	2,234	1,968	1,374
11-inch .	89,003	2,690	2,529	2,375	2,221	2,086	1,978	1,742	1,220
12-inch .	115,081	2,690	2,542	2,398	2,263	2,129	1,857	1,617	1,131

From the foregoing table it will be seen that at the different ranges below 4,374 yards—beyond that range it would be equivalent to emptying the ammunition rooms into the sea—all four of these guns pierce 6-inch Krupp armor at striking velocities of 1,624, 1,374, 1,220, and 1,131 feet, respectively, decreasing sensibly with the increase of the caliber. But the 12-inch armor, which is still to be found on some

ships, is not perforated by the 8-inch gun, except at very short range, which justifies the installation of two 12-inch guns on board the *Vittorio Emanuele*. This gun is able to perforate such armor at ranges even greater than 4,374 yards, while the 9.4-inch gun of the *Wittelsbach* and other German battleships, except the latest type of 13,000 tons' displacement, can do so only at ranges not exceeding 2,187 yards.

From this comparison of the armaments of modern battleships, the lecturer, while expressing admiration for the battery of twelve 8-inch guns of the *Vittorio Emanuele*, shows that the protection given these guns could be perforated by hostile 8-inch guns at ranges of from 3,281 to 4,374 yards.

The able author of this comparison forgets, however, two factors of the utmost importance in battle, namely, the oblique impact and the number of guns.

If we consider a curved redoubt, or a turret, or the redoubt which supports and protects the turrets below (not merely the ammunition-hoisting tube mentioned by Gillmor) of a thickness of 6 inches, like that of the 8-inch guns of the Italian ship, we must suppose that to have perforation the shot would have to strike exactly diametrically; for, with the exception of the trajectory represented by a generating line passing through the hostile gun and the center of our turret, all the other shots would be oblique, and hence less powerful. In addition it should be remembered that there are twelve of these guns, so that the probability of perforation of one of the six turrets constitutes danger to only one-sixth of our second-caliber battery. In my opinion, therefore, Sabath is mistaken when he compares an armament which is very numerous, both on board the *Vittorio* and the 8,000-ton design, with the 9.4-inch armament, which, in the case of the Austrian and German ships, is confined exclusively to the bow and stern. In view of the fact that the *Kaiser Karl VI* and *Radetzky* classes have only two of these guns, one forward and one aft, and the *Habsburg* class three in all, they must, of course, be given stronger protection than the 6-inch armor which is used for our twelve 8-inch guns. The bow and stern guns of the *Vittorio* are protected by 9.8 to 7.8-inch curved armor, although we do not assign to these guns the unusual importance given them in the *Duncan* and *Mikasa*, which seems to us out of proportion, especially when the enormous weight of their armor is considered.

The old conception establishing the empirical rule that the thickness of the armor must be equal to the caliber of the gun to be protected by it has served its time and can obviously no longer be sustained, in view of the great progress made in the face hardening of armor plate.

The proving ground, with its normal firing and with the target almost at the muzzle of the gun, is still misleading the ideas of some conservatives, especially in England; and the Japanese can not forget that

Admiral Ting, behind the thick armor of the *Chen Yuen*, was very "hard to cook."

But leaving this obsolete question and that of the number of guns and the thousands of rounds available for our many 8-inch guns as compared with the hundreds of rounds available for the few 9.4-inch German guns (because the objectives which we have assigned to the former have nothing in common with those of the latter), we will state that the velocities for perforating armor, as indicated in the above table, should be multiplied by at least $1\frac{1}{2}$ in order to make a rough allowance for the probable mean inclination of the shots, which can not all strike the hostile armor exactly at an angle of 90° . It is evident that such a computation has also been made by the authorities of the Austrian and German navies, for in spite of Sabath's arguments in favor of the 9.4-inch guns as compared with the larger calibers, they have decided, or are about to decide, to abandon this type of gun, which, in my opinion, is not equal to the purpose for which it is intended, and to equip their new ships with 11-inch bow and stern guns.

To sum up: What we want is to be able to perforate all the latest 6-inch armor plating, even at the long ranges at which hostile 6-inch shell can inflict only insignificant scratches on us. Firing at such ranges is not very accurate, but the target is large, and the 8-inch ammunition very plentiful and uniform. Then when we have silenced those 6-inch guns we want to be able to perforate the 12-inch belts at ranges superior to those of torpedoes, no matter at what angle these narrow belts may present themselves to the fire. In this second part of the programme the target is very limited, but 1,094 to 1,640 yards is not a long range, and if the sea is not very rough I believe one or the other of the 12-inch guns of the *Vittorio* will be able to put a hit into such belt, and the invulnerable "box" which is still adhered to in some types will speedily lose its metacenter, not toward the truck, but toward the keel.

FRENCH COMPARISONS.

Having arrived near the end of these notes I will add a brief summary also of other and less extensive studies and publications which have appeared abroad on the new Italian ships.

Le Petit Var, of Toulon, in its issue of May 24, 1901, published an article by Commander Vignot, the well-known editor of the *Marine Française*, on the comparative values of the *Vittorio Emanuele* and *Victor Hugo*. I will not follow the author in his arguments, but only call attention to the depth of his views and the kind reception he accords the new ideas introduced into the Italian type.

Thus also *Le Yacht*, in its issue of February 26, 1901 (p. 57), compares the *Vittorio Emanuele* with the English and French battleships and expresses the following opinion: "With a protection consisting of

a wide and complete armor belt of adequate thickness, namely, 9.8 and 7.8 inches (in this respect superior to the English battleships of larger displacement), well designed offensive power, an extensive radius of action, and a speed equal to that of the best armored cruisers, she would be much superior to the cruisers proposed in our new naval programme."

France in her naval objectives in the Mediterranean has certain points of resemblance with ours, and it is but natural, therefore, that certain types of ships would answer equally well the purposes of both navies.

After the two schools, one in favor of large ships and the other of medium-sized ships, had to fight last year about the French naval programme to be laid down, it seemed as though Mr. Lockroy's political friends were going to range themselves on the side of Minister Lanesan's party, which is desirous of building ships of 15,000 tons displacement like the English; but a slight financial flutter in connection with budgets has been sufficient to put new vigor into the defeated party and to start in the budget commission and in the Chamber a movement against the laying down of the other four large battleships which were to succeed the *Patrie* and *République*. We shall follow with the greatest interest the impending debate, because it will prove more than ever that our administration was on the right road a year ago in fighting naval programmes and demonstrating their instability and practical uselessness in view of the constant political and financial changes in the country. And noticing the contentions which have arisen in the United States among the different authorities called upon to give their opinions on the naval programme and the different types of ships, and the radical changes which have taken place in the course of a year in England's naval policy, we can see plainly how much more rational it has been to follow a system which is more immediate in its effects and more in harmony with our financial situation, namely, of selecting a moderate type and duplicating it immediately as many times as the capacity of our shipbuilding yards would permit.

Perhaps the French Chamber will follow the majority of its budget commission, and in that case the navy would acquire only two ships analogous to the English, but very different from the French ships now in existence, and not even having the advantage of being similar to future British ships, for in the meantime the naval policy in that country has undergone a change and the displacement made more formidable still in order to increase the medium calibers between the 12-inch and the 6-inch guns.

In case the victory should this time smile on Lockroy's ideas, we shall see France adopt the conceptions which I have advocated so many times and which it would be out of place to repeat in this connection.

Naturally *Le Yacht* opposes this conversion, while the *Marine Française* advocates it; but this is a trick with which our example has had

something to do, and we have reason to believe that such example has in a slight degree exerted an influence in lowering the value of the *Patrie* type—not to-day, but in view of the aspect which an action in the Atlantic would present in five years.

While in comparisons with French ships we have always pointed out their efficient armor belts, we have repeated again and again that the 2.5-inch protection of the cofferdams has had its day. It is not fear of maximite superseding melinite, nor that the recent tests will greatly modify the efficacy of such protection, but it is none the less true that it is of no avail to have the submerged part of a ship intact when the enemy can destroy at long range that 2.5-inch protection and everything that is above it. The adherence to this slight protection above the thick water-line belt in the *Patrie* type looks to me like a result far from modern, due perhaps to the fear of exceeding 14,865 tons and reaching a displacement of 15,000—the American fear, as previously stated.

GERMAN OPINIONS.

The German technical press also has repeatedly taken occasion to discuss the new Italian type and compare it with those of the German navy.

The able publication *Marine-Rundschan* (see issue of June, 1900, and May, 1901) has not deemed the remarks very accurate which I made last year about the German long-term naval programme, nor does it coincide with my opinions on the comparative technical improvements of these types of ships. It is not my intention in these brief impartial notes on foreign opinions as to our new ships to open up technical discussions as to types of ships. I have already said more than once that I am entirely familiar with the improvements made, both in the lines of the hull of German ships and in the disposition of their offensive and defensive means, and it therefore seems to me that I am competent to compare the new types with the preceding ones and to state that there is noteworthy progress. I have already spoken of the differences existing between the ideas prevailing in leading English circles as to the responsibility for designs and the new German ideas announced at Charlottenburg. We shall have to wait until the words have become facts, and then comparisons between the future battleships will tell more than any conjectures of ours could do.

Another review, *Schiffbau* (see Vol. I, 1900, p. 523, and Vol. II, 1901, p. 489), has expressed doubts as to the possibility of carrying, at 22 knots speed and about 20,000 horsepower, 12,600 tons, and has discussed particularly the point whether the lines which may facilitate such a result would be suitable in docking the ship, especially as regards the curvature of the keel. This last objection has to my mind so little weight that it deserves nothing more than to be mentioned to

show the interest that is being taken abroad in our new types. As to the speed of 21.5 or 22 knots, with 19,000 or 20,000 horsepower, with or without liquid fuel, with or without fine lines compatible with our low ratio of 5:9 between length and breadth, I need only refer to what I said last year relative to this new hull. (See *Rivista Marittima*, January, 1901, p. 42.)

Schiffbau rejoices in the fact that of the different navies the Italian has been the first to profit by the lessons of late naval actions and suppressed the heavy and dangerous military masts. It is my opinion that on a fast ship, with the inevitable vibrations of the tops, the fire of the small guns carried high up in the military mast is of very problematic effect. Considering that the *mêlée*, which alone justifies the use of these small weapons from such height, will probably not occur until after a lengthy duel at long range, we may conclude that in a close and decisive action the unprotected parts—masts, smokestacks, boats, and unprotected light guns—will be entirely destroyed.

Hence arises the necessity of protecting also the small-caliber guns if they are to be available at night against surprises from torpedo boats, or they should be dismounted and kept, during the great battle, inside of the redoubt.

As to boats, a few folding boats should also be kept in the redoubt, and around the smokestacks the draft should be increased to keep them standing, even though riddled, since the perforations will not prevent their thermic action, and those ships only whose boilers are not equipped for forced draft must expect great loss of speed if the smokestacks are cut off or knocked down.

Finally, *Schiffbau* doubts the possibility of having, with 12,624 tons displacement, the powerful armament of the *Vittorio Emanuele* and her armor, which is thicker than that of the British ships, including the *Bulwark* type. On that point I can relieve the fears of this foreign writer and of the still less charitable Italian writers, assuring them that everything has been planned with the minutest care, that no changes will be made, and that we have every reason to hope that certain mistakes which have occurred in the past in the equipment of ships will not be repeated in the case of this ship.

ENGLISH OPINIONS.

The English press has always given our designs special attention. I regret that I can not agree with the author of the article entitled "Warships and Mathematics" (*Engineer*, October 18, 1901), especially as to the mathematical part. Aside from the inaccuracies, among them the erroneous statement as to the armament of the *Vittorio*, that naval officer's system, *based chiefly on unwritten instinct*, seems rather dangerous to me; by its use some other writer, of a more amphibious instinct, might demonstrate that the *Narval* is the ideal engine of naval warfare.

Aside from this divergence of technical views, we can not but feel gratified at the courtesy shown in the comparison between the *Vittorio Emanuele* and the *Amalfi* (*Engineer*, March 15 and June 7, 1901), and in the criticism of my article on naval programmes, tending to explain the evolution of Italian naval architecture.

In a recently published criticism on Gillmor's work the same magazine (*Engineer*, January 3, 1902) concurs in the latter's doubts as to the speed and displacement of the *Vittorio*—doubts which constitute praise for us—and mentions the conclusions arrived at in the "symposium" of Fred T. Jane, the well-known inventor of the naval war game and founder of *All the World's Fighting Ships* (fourth year, 1901).

This "symposium" is also an instinct system, and we can therefore not attach much weight to the rating arrived at, because it is too extensive and takes in too much. The *Vittorio* and *Mikasa* came out ahead, but many of those called upon for opinions were not well acquainted with all the foreign ships, and the vote of some is not free from chauvinism, a thing almost inevitable when the needs of one's own country present themselves most forcibly to one's mind, and the ship which can best fill them naturally appears to be the one that ought to be preferred by others also.

A critical examination of the opinions and arguments of the eminent foreigners consulted would be interesting to students as indicating the currents which are influencing naval architecture. But it would lead us too far. I will only say that of the different writers a man like Cervera has probably a more accurate idea than the others of what a duel of naval ordnance would be in the near future.

The opinion of Mr. Watts, superintendent of the Armstrong works, would have been particularly interesting, because it might help us to determine in the future his influence on the new types which he will have to study when he takes Sir William White's post at the Admiralty. A new policy is already noticeable in the latest designs of the latter, and it is not impossible that this change is partly due to the evolution of new ideas which has taken place in the minds of some of the members of the Admiralty and to recent publications, and, to a small degree, also to the lecture delivered in May, 1901, at Portsmouth, by Lieut. Herbert W. Hope, on ships under construction, especially on the *Vittorio Emanuele* type, concluding with these words: "Everybody is very much struck by the new ships, the *Regina Elena* and the *Vittorio Emanuele III*. They are certainly beautiful ships, infinitely superior to any other battleship building."

CONCLUSION.

In former articles which I have published in this *Rivista* I have tried to condense in the last paragraph the ideas developed in the whole

work, in order to furnish busy readers an opportunity of gaining an idea of the question without having to read the whole article. But this time I must confess that I can draw no general conclusion from these brief notes.

Perhaps, if naval battles were the only probable actions in the future, the comparison of modern battleships might be more rational and more conclusive. But the objectives concerning coasts, and still more the colonial aims which mark the policy of this new century, introduce so many and such divergent contingencies in our inferences that a conclusion appears impossible.

And even considering only battles upon the open sea, it would not be easy to specify, with good reason, one particular type of battleship as the best, because, independently of the quality of the adversary, the number enters into the computation, and the variableness in the number of ships obviously exerts an influence which may at times affect the type.

It seems to me that problems of too wide latitude are as dangerous as those which are too narrowly defined. But if such were not the case, the comparison of the *Vittorio Emanuele* should at least have been confined to the future fast battleships of the French navy advocated by Lockroy, or of its 12,000 to 13,000 ton cruisers, and to the 13,680 and 15,960 ton ships of the United States Navy, and perhaps to the whole variegated series of the British ships, passing from the *Kent* to the *Drake* and *Duncan*.

Types are becoming more and more peculiar to the different nations. Never before has it been possible to embody so much power in medium-sized hulls by lessening the weight of the armament, armor, and boilers, while, on the other hand, three of the principal navies are pursuing a different, and surely easier, policy, consisting, as previously stated, in increasing the eggs by enlarging the basket.

It may be that Mr. Watts, instead of continuing this unlikely increase in displacement, will set a personal and perhaps national stamp upon the new type of battleship that will fully answer all the British objectives, and then perhaps, instead of the *Vittorio Emanuele*, we shall have a new English *Edward*, which, in my opinion, will better embody the various needs of England and can be more homogeneously associated with other foreign types in future comparisons of battleships.

Efficiencies per ton of displacement of 36 types of ships classified in the order of displacement.

CHARACTERISTICS OF EACH TYPE																																					
Type of ship.	BOGATYR.	KARL VI.	GARIBOLDI.	DESAIX.	RAYAN.	GUICHEN.	PROPOSED ARMORED CRUISER. ^a	O'HIGGINS.	HENRI IV.	MONTCALM.	ASAMI.	KENT.	CONDE.	FILIBERTO.	BISMARCK.	DIADEM.	CHARLE-MAGNE.	JEANNE D'ARC.	KAISER FRIEDRICH.	CALIFORNIA.	JÉNA.	GRESSY.	MAINE.	RENOUW.	GROMOBOL.	VITTORIO E.	SUFFREN.	CANOPUS.	REGINA MARGHERITA.	RE UM-BERTO.	DUNCAN.	DRAKE.	POWERFUL.	MAJESTIC.	SHIKSHIMA.	FORMID-ABLE.	
Nationality	Russia.	Austria.	Italy.	France.	Russia.	France.	Italy.	Chili.	France.	France.	Japan.	England.	France.	Italy.	Germany.	England.	France.	France.	Germany.	United States.	France.	England.	United States.	England.	Russia.	Italy.	France.	England.	Italy.	Italy.	England.	England.	England.	England.	England.	Japan.	England.
Displacement tons.	6,000	6,250	7,500	7,710	7,800	8,277	8,350	8,636	8,948	9,650	9,850	9,965	10,160	10,200	10,820	11,000	11,275	11,329	12,000	12,000	12,081	12,150	12,500	12,550	12,550	12,621	12,728	12,950	13,127	13,893	14,000	14,200	14,250	14,900	14,900	15,000	
Heavy guns (7 to 12-inch) inch.	2—7.9	2—9.45	1—9.81 2—7.9	0	2—7.9	0	1—11.81 10—7.91	1—7.9	2—10.6	2—7.5	4—8.0	0	2—7.5	4—9.84	4—9.45	0	4—11.81	2—7.5	4—9.45	4—8.0	4—11.81	2—9.0	4—12.0	4—10.0	1—7.87	2—11.81 12—7.87	1—11.81	1—12.0	4—11.81 4—7.87	4—13.4	4—12.0	2—9.0	2—9.0	4—12.0	4—12.0	4—12.0	
Medium caliber guns (4 to 7 inch) do.	8—5.91	8—5.91	11—5.91	10—6.3	8—5.91	2—6.3 6—5.5	0	10—5.91 1—4.72	7—5.5	8—6.3 1—4.0	14—6.0	14—6.0	8—6.3 6—4.0	8—5.91 8—4.72	12—5.91	16—6.0	10—5.5 8—4.0	14—5.5	18—5.91	16—6.0	8—6.3 8—4.0	12—6.0	16—6.0	10—6.0	14—5.91	6—12—4.0	10—6.3 8—4.0	12—6.0	12—5.91	8—4.72	12—6.0	10—6.0	12—6.0	12—6.0	14—6.0	12—6.0	
Energy of fire in 5 minutes foot tons	913,385	737,154	1,117,714	943,266	913,385	652,333	1,702,768	1,545,857	677,088	1,278,571	1,677,491	1,044,954	1,405,311	1,156,933	1,175,750	1,194,233	1,765,461	1,352,400	1,623,588	1,677,491	1,747,275	1,018,035	1,679,938	972,362	1,677,491	2,576,000	1,935,928	1,381,380	2,013,916	991,211	1,381,380	868,756	1,018,035	1,381,380	1,530,659	1,381,380	
<i>Prot. cruiser.</i>																																					
Armor belt inches.	0.0	8.66	5.91	3.91	7.87	0.0	7.87	7.00	11.00	5.91	7.00	4.00	5.91	9.84	7.87	0.0	15.7—11.8	5.91	11.8—11.00	6.00	13.2—12.2	6.00	12.00	7.87	5.91	9.84	11.8—11.0	6.00	5.91	3.94	7.00	6.00	0.0	9.00	9.00	9.00	
Indicated horsepower	19,500	12,000	13,500	17,100	6,500	23,000	19,000	16,000	11,500	19,600	18,000	22,000	20,000	13,500	19,000	16,500	15,000	20,500	13,500	24,000	15,500	21,000	16,000	12,000	18,000	19,000	16,000	13,500	19,000	19,000	18,000	30,000	25,000	12,000	15,000	15,000	
Punker capacity tons	1,000	800	1,000	1,200	1,000	2,100	2,100	1,200	1,100	1,600	1,200	1,600	1,600	1,000	1,000	1,000	1,100	2,100	1,000	1,800	1,100	1,600	2,000	1,800	2,500	2,000	2,000	1,850	2,000	1,700	2,000	2,000	3,000	1,850	1,400	2,000	
EFFICIENCY PER TON OF DISPLACEMENT																																					
Armament.																																					
Energy per ton of displacement foot-tons.	152.23	118.0	189.01	122.36	116.9	78.8	203.9	179.0	75.67	132.5	170.4	104.8	138.3	113.4	108.6	108.5	156.7	119.3	135.3	139.7	144.5	83.8	134.5	77.5	134.0	204	132.1	107.0	150.0	71.6	99.0	61.1	71.4	92.7	93.5	92.0	
Decimal efficiency	0.65	0.42	0.89	0.44	0.38	0.15	1	0.83	0.11	0.51	0.78	0.33	0.55	0.33	0.35	0.35	0.67	0.42	0.54	0.55	0.60	0.17	0.54	0.13	0.54	1	0.67	0.33	0.65	0.08	0.29	0	0.08	0.24	0.31	0.22	
Performance.																																					
Of longest guns inches of iron	20.9	26.0	27.6	15.7	20.9	15.7	37.0	20.9	32.3	17.7	20.9	15.7	17.7	27.6	26.0	15.7	35.8	17.7	26.0	20.9	35.8	26.0	37.0	27.6	20.9	37.0	35.8	37.0	37.0	32.7	37.0	26.0	26.0	37.0	37.0	37.0	
Decimal efficiency	0.24	0.46	0.56	0	0.24	0	1	0.24	0.78	0.09	0.24	0	0.09	0.56	0.46	0	0.95	0.09	0.46	0.24	0.95	0.46	1	0.56	0.24	1	0.95	1	1	0.80	1	0.46	0.46	1	1	1	
Protection.																																					
Hit tons per 1,000 tons displacement	0.0	1.39	0.79	0.54	1.02	0.0	0.95	0.79	1.22	0.59	0.71	0.39	0.59	0.95	0.75	0.0	1.06	0.51	0.92	0.51	0.98	0.51	0.95	0.63	0.47	0.79	0.87	0.47	0.18	0.27	0.47	0.13	0	0.59	0.59	0.59	
Decimal efficiency	0	1	0.58	0.38	0.75	0	0.69	0.57	0.89	0.43	0.52	0.29	0.43	0.69	0.55	0	0.77	0.38	0.67	0.38	0.72	0.38	0.59	0.46	0.35	0.57	0.64	0.35	0.31	0.20	0.35	0.34	0	0.43	0.43	0.48	
Speed.																																					
Fenths of knot per 1,000 tons	38	32	26	27	27	28	28	25	19	22	22	23	21	18	17	18	16	20	15	18	15	17	14	14	16	17	14	14	15	14	13.5	16	15	11	12	12	
Decimal efficiency	1	0.78	0.56	0.59	0.59	0.63	0.63	0.52	0.30	0.41	0.41	0.45	0.37	0.26	0.23	0.26	0.19	0.34	0.15	0.26	0.15	0.23	0.11	0.11	0.10	0.23	0.11	0.11	0.15	0.11	0.09	0.10	0.15	0	0.04	0.04	
Radius of action.																																					
At 10 knots miles per ton	1	0.5	1.1	1	1	1.1	1.8	0.9	0.9	1.03	0.7	0.8	0.9	0.73	0.6	0.7	0.7	0.92	0.4	0.7	0.1	0.6	0.6	0.5	0.9	0.9	0.6	0.7	0.75	0.5	0.6	0.7	0.9	0.45	0.3	0.5	
Decimal efficiency	0.55	0.25	0.60	0.55	0.55	0.60	1	0.50	0.50	0.57	0.89	0.44	0.50	0.41	0.33	0.39	0.39	0.51	0.22	0.39	0.22	0.33	0.33	0.28	0.50	0.50	0.33	0.39	0.42	0.28	0.33	0.89	0.50	0.25	0.17	0.28	
Total efficiency	2.44	2.01	3.19	1.96	2.52	1.38	4.32	2.66	2.58	2.01	2.34	1.51	1.94	2.30	1.92	1.00	2.97	1.74	2.04	1.82	2.64	1.57	2.67	1.54	1.82	3.30	2.70	2.18	2.53	1.47	2.06	1.35	1.14	1.92	1.95	1.97	
Maximum speed	23	20	20	21	21	23	23	21	17	21	21	23	21	18	19	20	18	23	18	22	18	21	18	18	20	21	18	18	20	19	19	23	21	17	18	18	
Year	1900	1899	1899	1900	1900	1898	1900	1897	1899	1899	1899	1900	1900	1899	1897	1897	1896	1890	1898	1900	1898	1899	1899	1895	1899	1901	1899	1897	1900	1892	1899	1900	1896	1894	1899	1899	
<i>N. B.</i> —The comparison refers to an imaginary ship having the designs under consideration and uniting these factors in the smallest displacement. This imaginary design, therefore, obtained the maximum efficiency of 1 for each factor, or a total efficiency of 5. But when the energy developed by the guns in 5 minutes, recorded in the above table on the basis of rapid loading, is reduced to the energy which could be actually attained in battle with practicable aiming, the total efficiency would be modified as follows:																																					
	2.21	2.84	2.99	1.72	2.36	1.27	4.32	2.42	2.56	1.78	2.15	1.33	1.67	2.17	1.88	0.84	2.80	1.57	1.93	1.70	2.47	1.40	2.63	1.54	1.66	3.30	2.50	2.18	2.50	1.42	2.06	1.35	1.14	1.92	1.95	1.97	

^a The characteristics of this ship, on which the *Vittorio Emanuele* is based, are stated in the *Revista Marittima* for December, 1899, page 440, and for January, 1901, p. 41.

^b The energy of this 4-inch gun has not been computed on the basis of rapidity of loading, as in the case of the *Conde*, *Montcalm*, etc., but on the basis of 5 rounds a minute.

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